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Carphodactylus laevis, the rainforest gecko, from Mossman Gorge Queensland. See paper on p53. (photo by Geordie A. Torr)

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REVIEW OF THE STATUS AND ASSESSMENT OF THE HABITAT OF THE STUTTERING FROG *MIXOPHYES BALBUS* (ANURA: MYOBATRACHIDAE) ON THE SOUTH COAST OF NEW SOUTH WALES

Garry Daly c/- North Nowra PO. 2541

ABSTRACT

Tadpoles and adult Stuttering Frog *Mixophyes balbus* were detected in the ecotone between closed and tall open forest at altitudes of 50-900m asl. *Mixophyes balbus* tadpoles detected in the upper portion of a creek were benthic and hid under leaf litter and other organic debris at the bottom of small shallow pools. Some pools contained native fish. Tadpoles were dark brown/black, grew to 25 mm snout-vent and 64 mm in total length and metamorphosed at 25-28 mm snout-vent length in January. A high mortality of tadpoles was observed during the early stage of their development. Based on current data the conservation status of *Mixophyes balbus* warrants reappraisal.

INTRODUCTION

The range of the Stuttering Frog *Mixophyes balbus* differs according to which references are viewed. Barker, Grigg and Tyler (1995) state that the species occurs on the east coast from southern Queensland through New South Wales to the northern tip of eastern Victoria while Cogger (1992) and Ferrier *et al.* (1993) indicated that *M. balbus* does not occur in Queensland. The latter reference states that the species northern limit is the Gibraltar Range and the Clarence River.

Mixophyes balbus has not been located in recent years in Victoria and has been infrequently detected on the south coast of New South Wales (NSW) (W. Osborne pers. comm., Lemckert *et al.* 1997, pers. obs.) and populations have declined immediately north of Sydney (Mahony 1993). Nine State Forests management areas in NSW covering some 947,834 ha which lie within the known distribution of *M. balbus* were surveyed during the late 1980's early 1990's and the species was only detected in two of these areas (see Table 2). The species is described by Tyler (1992) as common and secure which belies its current status in NSW (Schedule 2 of the *Threatened Species Conservation Act* TSC Act, 1995) and Victoria.

There is a general absence of detail of the vegetation communities where *M. balbus* has been detected. Barker *et al.* (1995) state the species occurs in rainforest in the mountains while Tyler (1992) describes the habitat as temperate wet sclerophyll forest. Webb (1991) caught juveniles on the New South Wales/ Victoria border adjacent to a creek in tall open forest where the dominant tree species were *Eucalyptus obliqua* and *E. cypellocarpa* (altitude 500-800m asl).

There is also an absence of detail regarding the morphology and behaviour of *M. balbus* tadpoles. Tyler (1992) states that the tadpole maximum length is unknown although Barker *et al.* (1995) reported that it is similar to that of the Great Barred Frog *M. fasciolatus*.

Mixophyes balbus was studied as part of a body of work that seeks to describe the distribution, habitat preference and behaviour of amphibians. These field based studies identify and hence aid the conservation of 'threatened' species critical habitat. Descriptions are given of tadpole behaviour and morphology. These descriptions may be useful in identifying the species in the field at times when adult frogs are inactive. Identification based on tadpoles may also help resolve the apparent uncertainty in the species distribution.

A review is given of the survey effort for frogs undertaken for State Forests during recent fauna surveys so that an assessment can be made on the status of *M. balbus*.

METHODS

Mixophyes balbus tadpoles were observed in the upper lateral of Kellets Creek north west of Nowra, NSW (34°50'S, 150°27'E). Tadpoles were collected using dip nets and the number was determined during a survey of approximately 400m of creekline (Table 1). The dimensions of pools where tadpoles were located are given. A few tadpoles were retained and maintained in plastic buckets until metamorphosis to verify the species identity. The area was resurveyed several times to ascertain breeding, growth rate and the time taken for tadpoles to complete metamorphosis under natural conditions.

Mixophyes balbus tadpoles were also located at Helensburgh in a lateral of the Port Hacking River (34°10'S, 150°49'E) Chaelundi State Forest (29°57'S, 152°20'E) and adults and tadpoles at Stanwell Park (Hargraves Creek) New South Wales (34°14'S, 150°59'E). The vegetation communities within ten metres of each site are described along with other details of habitat.

Consideration of the status of *M. balbus* is given by reviewing surveys undertaken on behalf of State Forests of NSW and the NSW National Parks and Wildlife Service. These results are tabulated so that survey effort can be evaluated against the detection rate of *M. balbus*.

RESULTS

Sites in the Illawarra

In October 1994 Nowra was in drought and twelve *M. balbus* tadpoles were found within a 20 m section of the Kellets Creek in seven small residual pools (potholes) at 50 m asl (Table 1). These pools were stagnant and stained with tannin. The creek had a sandstone substrate and the tadpoles were found in the area where the slope was gentle (ie approximately 1:10). The land on either side of the creek was steep (ie approximately 1:3).

The vegetation community adjacent to where *M. balbus* tadpoles were detected was tall open forest which had closed forest species in the mid to lower canopy. The overstorey was Turpentine *Syncarpia glomulifera* and Bangalay/ Blue Gum *Eucalyptus botryoides/ saligna* cross. The mid storey consisted of Coachwood *Ceratopetalum gummifera*, Ironwood *Backhousia myrtifolia*, Cabbage Tree Palm *Livistona australis* and Lilly Pilly *Acmena smithii*. Beside the creek King Fern *Todea barbara*, False Bracken *Culcita dubia*, Shiny Fan Fern *Sticherus flabellatus*, Fishbone Water Fern *Blechnum nudum* and Rough Treefern *Cyathea australis* were present. Approximately five metres from the creek the understorey was sparse and covered with leaf litter.

Mixophyes balbus tadpoles had benthic habits and hid under organic debris. Some tadpoles were found in pools which contained Mountain Galaxias *Galaxias brevipennis* and Cox's Gudgeon *Gobiomorphus coxii* (Table 1). *Galaxias brevipennis* were found in the same creek at 180m asl (M. Murphy pers. comm.).

The tadpoles were dark brown/black and when held in plastic clip bags often held the side of the bag with their mouth. Those raised in captivity grew to 25 mm snout-vent and 65 mm in total length (Figure 1), and metamorphosed during January 1995. Metamorphlings measured between 25-28 mm snout-vent length, did not have an upper blue iris but did possess distinct dark nasal patches and were released at the point of capture.

On 31 January 1996 the site was revisited and 23 small tadpoles were found in two pools some 50m downstream from where animals had been located in 1994. The stream was flowing at this time. Eels *Anguilla reinhardtii* ?, *G. brevipennis* and Yabbies were observed in the creek but not in the pools that possessed tadpoles. Tadpoles lay on the bottom of these pools and fed on algae which grew on the bedrock. If disturbed they hid amongst piles of small rounded stones and organic debris which had been deposited into the potholes. Tadpoles were sedentary and were found in either the same or adjacent pools after rain events. Two tadpoles were measured and were 6-7 mm

(snout - vent) and 13-14 mm (total length). The size of these tadpoles indicated that breeding had recently occurred. This population was resurveyed three times over 11 months in which time the tadpoles grew to 25 mm (s-v) and 64 mm (t-l), at Gosner stage 37. Within the first three months the number of tadpoles was reduced to six and the large pool where the majority of tadpoles were located was dry. During this time the temperature of the creek ranged from 12.2°C to 19.2°C.

The site was resurveyed on 11 April 1997 and no tadpoles were observed. However, on 3 April 1998, 19 *M.Balbus* tadpoles were found in 5 pools within 10m of creek. They were in the same section of creek where tadpoles were found in 1994. One pool had a tadpole and an Eel. One tadpole was albino. The tadpoles ranged in size from 11-22mm (s-v) 30-56mm (t-l). No tadpoles were found in large deep pools over the four years that the site was surveyed.

During late February 1994 approximately 200 *M. balbus* tadpoles were found in a lateral of the Port Hacking River at Helensburgh (J. Rice pers. comm.). The substrate was sandstone. Based on regrowth the area had experienced fire probably two years previously. The pool where the tadpoles were observed was approximately 50m downstream from a 5 x 5 x 50 m long tunnel at 160m asl. The slope at this point was gentle and was approximately 1:10.

The vegetation community adjacent to the creek was open forest and contained Redgum *Angophora costata* and Blackbutt *Eucalyptus pilularis* which had an understorey of Illawarra Lilies *Doryanthes excelsa*. Immediately beside the creek was Black Wattle *Callicoma serratifolia*, depauperate *C. gummifera*, Sweet Pittosporum *Pittosporum undulatum*, River Lomatia *Lomatia myricoides*, Willow-leaved Hakea *Hakea salicifolia* and Ceder Wattle *Acacia elata*. The area was resurveyed on 4 February 1995 and no *M. balbus* tadpoles were found.

During 1982 *M. balbus* were observed in Hargraves Creek at Stanwell Park. The substrate was siltstone and the pool fish free. Tadpoles were in a pool some 3 x 3 x 1.5 m deep at 100 m asl. The site was approximately 10 m downstream from a 2 x 2 x 50 m long tunnel. A pair of *M. balbus* were observed in the upper mouth of the tunnel after intense rain in January 1982? The slope immediately above the pool was approximately 1:4.

The vegetation in the area varied either side of the tunnel from tall open forest to closed forest. Down stream from the tunnel the open forest consisted of *S. glomulifera* which had an understorey of *P. undulatum* and *L. australis* whereas upstream closed forest consisting of *C. gummifera*, *P. undulatum*, Brown Beech *Pennantia cunninghamii* and Sandpaper Fig *Ficus coronata*. No tadpoles or adult frogs were detected during single surveys in late December 1994 or January 1996.

On 7 December 1993 *M.Balbus* tadpoles were detected in the upper portion of a stream at Chaelundi State Forest. The site had an altitude of 800 m asl and the substrate was volcanic rock. The vegetation community adjacent to where *M.Balbus* tadpoles were detected was tall open forest which had closed forest species in the mid to lower canopy. The overstorey was Brushbox *Lophostemon conferta* and the mid storey contained Treeheath *Tropocarpa laurina* and Sandpaper Fig *Ficus coronata*. The site was resurveyed on 10 October 1995 and several hundred tadpoles were found in large pools (ie 3x1x1m). On both occasions *Lechriodus fletcheri* spawn were found in small pools beside the main creek.

In Victoria there have been three records within East Gippsland. The species was not recorded in the last 10 years by pre-logging surveys, nor by recent targeted surveys of known localities and other areas of suitable habitat (G. Gillespie in East Gippsland Regional forest agreement process 1996).

Table 1 Pools where *M. balbus* tadpoles were found at Nowra. Pool dimensions are in centimetres, the last measurement is depth

Pool	Date	Pool Size (cm)	Observation
1	-/6/94	not measured	2 *Mixophyes balbus* tadpoles observed
1	-/12/94	110 x 60 x 15	1 *Gobiomorphus coxii* and 3 *M. balbus* tadpoles
2	-/12/94	370 x 60 x 17	1 *G. coxii*, 3 *G. brevipennis* and 2 *M. balbus* tadpoles
3	-/12/94	50 x 30 x 10	3 *M. balbus* tadpoles
4	-/12/94	40 x 30 x 15	1 *M. balbus* tadpole
5	-/12/94	100 x 50 x 15	1 *M. balbus* tadpole
6	-/12/94	100 x 30 x 10	1 *M. balbus* tadpole
7	-/12/94	150 x 40 x 20	1 *G. brevipennis* and 1 *M. balbus* tadpole
	28/1/95		Metamorphling released and no tadpoles detected in creek
8	31/1/96	200 x 100 x 10	21 *M. balbus* tadpoles + I *L. phyllochroa* tadpole. Temp 18.4°C (water)
9	31/1/96	100 x 40 x 15	2 *M. balbus* tadpoles Length 6-7 mm (s-v) 13-14 mm (t-l). Temp. 19.2°C (water)
8	30/4/96	80 x 80 x 7	4 *M. balbus* tadpoles Length 16-18 mm (s-v) 40-46 mm (t-l). Temp. 12.2°C (water)
9	30/4/96	60 x 20 x 7	2 *M. balbus* tadpoles length 16-18 mm (s-v) 41-45 mm (t-l)
9	31/10/96	75 x 70 x 5	3 *M. balbus* tadpoles length 19-23 mm (s-v) 46-59 mm (t-l)
9	23/12/96	80 x 80 x 5	1 *M. balbus* tadpole length 25 mm (s-v) 64 mm (t-l)
10	23/12/96	70 x 26 x 6	1 *M. balbus* tadpole length 25 mm (s-v) 60 mm (t-l). Temp 18.0°C (water)
9	11/4/97	not measured	No tadpoles detected in creek. Temp 12.6°C (water)
11	3/4/98	140 x 30 x 14	1 *M. balbus* tadpole length 20 mm (s-v) 50 mm (t-l) Anguilla reinhardtii ? 300mm (s-v). Temp. 14.1°C (water)
12	3/4/98	190 x 30 x 4	3 *M. balbus* tadpoles length 18-20 mm (s-v) 43-55 mm (t-l), one albino
13	3/4/98	40 x 30 x 10	1 *M. balbus* tadpole length 22 mm (s-v) 56 mm (t-l)
14	3/4/98	60 x 33 x 24	4 *M. balbus* tadpoles length 11-18 mm (s-v) 30-40 mm (t-l)
15	3/4/98	150 x 40 x 15-180	10 *M. balbus* tadpoles length 13-15 mm (s-v) 31-40 mm (t-l) . Water flowed through pool. Approximately half the pool was shallow.

Table 2. Search Effort and threatened species of frog detected during surveys of State Forests

Management areas noted with an * are probably outside the range of *M. balbus*.

Management Area	Survey Effort	Threatened Species Detected
Eden- Bondi State Forest (Rockton Section) Fanning (1990) Size 16, 744 ha Altitude 370-906m asl Location: 37°0'-37°15'S 149°15'-149°35'E	Eleven days spent in the field. A few day and night searches.	5 frog species No threatened species detected.
Queanbeyan/Badja * QEM (1994), Goldingay *et al.* (1995) Size 79,000 ha Altitude 300-1469m asl Location 35°20'-36°14'S 149°27'- 149°42'E	20, 500m transects with 5 dry pitfall lines containing 5 pits/line + drift fence. 10 ponds + 11 creeks surveyed. 9 days specific surveys for endangered frogs.	12 frog species. No threatened species were detected.
Narooma/Batemans Bay Wells and Wellington (1995) Size 105,000 ha Altitude 0-1300 m asl Location 35°50'-36°45'S 149°40'-150°05'E	Special searches 4/ 30 min nocturnal plot searches for frogs. Opportunistic searches.	9 frog species 1 *Heleioporus australiacus*
Morisset Wells and Wellington (1995) Size 115,987 ha Altitude 60-480m asl Location 31°30'-33°30'S 150°20'-151°34'E	44, 500m transects with 2 wet pitfalls/15 days. 146 special searches.	23 frog species *Pseudophryne australis* detected in three separate pitfall transects.
Wingham Clancy (1992) Size 58250 ha Altitude 130-1200m asl Location 31°00'-33°15'S 151°45'-152°30'E	45, 500m transects with 5 wet pitfalls/ transect/ 2 weeks. 9 special searches	11 species of frog. *Litoria subglandulosa*
Gloucester/Chichester Ecotone Ecological Consultants[1] (1995), White[2] (1994) Size 117,000 ha Altitude 200-1500m asl Location 31°45'-32°15'S 151°15'-151°55'E	[1]52/500m transects with 5 wet pitfalls/transect/ 2 weeks. 3 special searches. [2]116 frog survey sites over 13 nights. Use of playback of frog calls.	[1]19 frog species. 1 *Mixophyes balbus* [2]22 frog species *Litoria subglandulosa* *Mixophyes balbus* tadpoles located at four sites

Management Area	Survey Effort	Threatened Species Detected
Coffs Harbour/Urunga Smith *et al.* (1995) Size 158,434 ha Altitude 0-1013m asl Location 29°23'-30°25'S 152°29'-153°16'E	60, 500m transects with 2 wet pitfalls/transect/ 2 weeks (min) + opportunistic searches. 28 special frog searches/ 30min/ search along creeks and drive searches and 7 wetland/ creek searches.	20 frog species many *Mixophyes iteratus*
Dorrigo Lim (1995) Size 27,219 ha Altitude 200-1380m asl Location 29°45'-30°25'S 152°15'- 153°00'E	Special frog searches for seven nights covering 123 aquatic sites.	27 frog species *Litoria subglandulosa* *Assa darlingtoni* *Mixophyes balbus* (several) *Mixophyes iteratus* (several) *Philoria sphagnicolus*
Walcha/Nundle Mt King Ecological Services[1] (1995), Webber[2] (1995) Size 120,000 ha Altitude 145-1470m asl Location 30°00'-31°45'S 151°15'- 152°20'E	[1]56, 500m transects with 5 dry pitfalls/ transect/ 2 weeks. 19 special search sites. [2]22 sites sampled over 8 nights/2 persons for a total of 70 hrs	[1]16 frog species *Philoria sphagnicolus* [2]13 non threatened frog species
Grafton/Casino Smith *et al.* (1994) Size 229,200 ha Altitude 150-1100m asl Location 28°35'-30°10'S 152°15'- 153°20'E	77, 500m transects with 2 wet pitfalls/ transect/2 weeks. Opportunistic searches.	20 frog species 1 Calling *Philoria* sp.
Tenterfield Fanning (1995) Size 90,000 ha Altitude 420-1140m asl Location: 28°52'-29°22'S 152°07'- 153°22'E	36, 500m transects with 10 wet pitfalls /transect. Opportunistic searches. 6 ponds/creeks searched.	17 frog species 1 *Litoria subglandulosa* 1 *Philoria loveridgei*
Urbenville* Austeco Environmental Consultants (1994) Size 75,000 ha Altitude 200-2000m asl Location 28°15'-28°45'S 152°00'- 153°00'E	36, 500m transects with 2 wet pitfalls/transect/ 2 weeks (min). Opportunistic searches	17 frog species 1 *Mixophyes fleayi* ? 2 *Philoria loveridgei*

Management Area	Survey Effort	Threatened Species Detected
Murwillumbah* CSIRO (1996) Size 3, 000, 000 ha Altitude 0-1156m asl Location 28°16'-28°39'S 153°06'-153°34'E	Over four days 51 point surveys conducted for three 20/min search time/person within 50m from point centre, one each during the morning, afternoon and evening. Surveyed once. Eight pitfalls set for four days at each point and aligned in two lines of 4 in a T or L shape with 30cm drift fence. Turtle traps and opportunistic surveys.	23 frog species Many *Assa darlingtoni* *Crinia tinnula* 1 *Mixophyes iteratus* *Philoria loveridgei*

Note: The author detected *M. balbus* during the Dorrigo fauna survey at approximately 900 m asl

Table 3 Search Effort and threatened species of frog detected during surveys for the NSW National Parks and Wildlife Service Comprehensive Regional Assessment, Southern and Eden Zones

Area		Survey Effort	Threatened Species Detected
1997	NSW/Victorian border north to Termeil State Forest (Batemans Bay) Altitude 10-1200m asl Location: 35°30'-37°0'S/149°15'-150°23'E	105 nocturnal streamside searches each 200 m/60 minutes. At some sites *Mixophyes balbus* call playback broadcast. Opportunistic surveys.	13 species of frog detected. One *Heleioporus australiacus* detected
1998	South coast NSW from Batemans Bay to Nowra. Altitude 3-740m asl Location: 34°45'-35°45'S/150°00'-150°50'E	17 nocturnal streamside searches each 200m/30 min. Opportunistic surveys.	15 species of frog detected. *Heleioporus australiacus* tadpoles detected at one site (ie Red Rock NR see Daly 1996)

DISCUSSION

Tadpoles were found in potholes and shallow rocky expanses of small sections of Kellets Creek in tall open forest/closed forest ecotone within 50m over four years which suggests adult frogs were reasonably site specific where they bred. Tadpoles were also sedentary even after rain raised the creek's height and flushed the pools. They probably maintain their position during floods by sucking onto the substrate as they do to containers when water is being decanted.

Mixophyes balbus lay between 500-550 eggs in shallow water in the riffle zone of creeks (R. Knowles pers. comm.). This is in agreement with the current observations of hatchlings and tadpoles occurring in shallow (100mm) water and larger tadpoles downstream from tunnels where shallow water riffles. The number of tadpoles found at Nowra indicates that the adult population of frogs is small (possibly one pair) and tadpole mortality at this site was high.

Small tadpoles are generally eaten by Galaxias, Gudgeons and Eels (pers. obs.) and hence oviposition sites which are in shallow water adjacent to small pools appear important for *M. balbus* at sites which possess fish. Even though large *M. balbus* tadpoles were found in pools with fish they may have avoided these predators by either being too large/distasteful or by hiding in the tannin stained water under debris. The sedentary nature of tadpoles may also reduce the risk of predation. However, utilising small pools may incur some disadvantages such as the risk of dehydration during drought and competition between siblings.

Mixophyes balbus tadpoles have been reported to be similar to that of *M. fasciolatus* (Barker *et al.* 1995). This statement in inaccurate as *M. fasciolatus* tadpoles grow up to 40 mm (snout - vent) and 98 mm in total length (unpub. data) whereas *M. balbus* upper limit was 25 and 64 mm respectively. There are other physical differences in the morphology of the specie's tadpoles (see Figures 1 and 2).

Observations on wild and captive tadpoles indicated that the aquatic phase of *M. balbus* life cycle takes approximately one year. Breeding probably occurred in January. However, this means that surveys for the species, based on the presence of tadpoles, can be conducted outside the period when adult frogs are active.

Mixophyes balbus was found at 50-900 m asl and the specie's habitat preference was foothills and montane areas, especially beside small creeks that had shallow rocky expanses that ran through tall open/closed forest ecotone. Although *M. balbus* occurs over a range of latitudes and altitudes breeding sites appear to be relatively specific. This specificity may account for the specie's rarity.

The status of *M. balbus* in NSW warrants reconsideration as it has only been found south of Sydney at Helensburgh, west Nowra, Dampier and Mumbulla State Forests (Lemckert *et al.* 1997, this study) since 1994. Recent surveys in northern Victoria (S. Halloway pers. comm.) and the central coast of NSW failed to find *M. balbus* (Mahony 1993) although a population exists in the Bulahdelah region (C. Slatyer, State Forests, pers. comm.). Fauna Assessments of nine State Forests in New South Wales, which lie within the known range of *M. balbus*, covered over 947,834 ha, only revealed a few animals in Gloucester/Chichester and Dorrigo management areas.

Mixophyes balbus is rare and exists in scattered populations. Based on current information the specie's status should be re-evaluated and possibly placed on Schedule 1 of the TSC Act and considered for inclusion on the federal *Endangered Species Protection Act 1992*.

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Figure 1. Dorsal and lateral view of *M.balbus* tadpole.

Mixophyes balbus Length (s- v) 15mm (t - l) 48mm

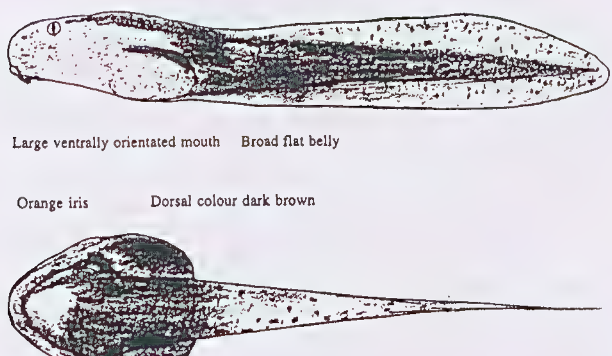
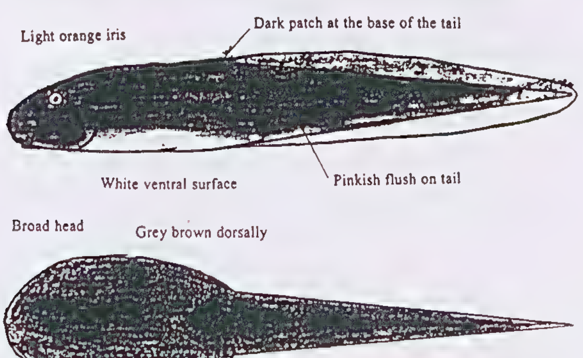


Figure 2. Dorsal and lateral view of *M. fasciolatus* tadpole.

Mixophyes fasciolatus Length (s- v) 36mm (t - l) 92mm



NOTES ON THE OCCURRENCE AND HABITS OF *POGONA BREVIS*

Grant Turner 103 Settlement Road, Bundoora, Victoria 3083.
Robert A. Valentic 11 Mulgowrie Court, Greensborough, Victoria 3088.

INTRODUCTION

Pogona brevis Witten 1994 is a medium sized *Pogona* confined to the black-soil plains region of central and western Queensland, from Gregory Downs to Longreach and Aramac (Witten 1994a, Shea 1995). The species has a somewhat unstable taxonomic history. It was originally described by Wells & Wellington (1985) as *Pogona henrylawsoni* in their controversial taxonomic revision of the Australian herpetofauna. Following (unsuccessful) moves to have this work suppressed (ASH 1987, ICZN 1991), the species and species name, failed to gain acceptance by most authors. The species was present in live captive collections since the early 1970's in both the USA and Germany where it was known as *Amphibolurus 'rankini'*. It is only briefly referred to in books by Wilson & Knowles (1988) and Ehmann (1992), and treated as an undescribed species in both; it is not referred to in Cogger (1986, 1992). Witten (1994a) described the species as *P.brevis* on account of a failure to locate the holotype and the claimed inadequacy of the Wells & Wellington (1985) diagnosis of *P.henrylawsoni*. Shea (1995) subsequently claimed these actions were invalid and proposed the retention of the original name (*P.henrylawsoni*) on the grounds of stability. Given our use of Witten's (1994) diagnosis to positively identify specimens and the appearance of several recent articles (de Vosjoli & Mailloux 1996, Rybak 1996) using *P.brevis*, we have elected to use this species name here pending formal resolution of the correct species name.

There is currently little information available on the natural history of the black-soil plains bearded dragon, *Pogona brevis*. In Wilson & Knowles (1988) the photographed specimen is from Winton, Qld with the comment "Moderately small very robust *Pogona* with poorly developed 'beard'. Apparently restricted to deeply cracking clay soils (black-soil plains) in interior of Qld" (p.220). Ehmann (1992, p.138) refers to it as the black-soil bearded dragon (*Pogona* sp.) and provides a brief description and comment on its escape behaviour. Greer (1989, p.13) refers to the species as '*P.henrylawsoni*' but no information is presented on the species' biology. The species has been successfully maintained in some USA and German collections for more than 20 years where it has been repeatedly bred (Michl 1986-7, de Vosjoli & Mailloux 1993, p.47, 1996); it has also been bred at Melbourne Zoo (see Witten 1994b).

Our observations of *P.brevis* relate to a brief excursion through the black-soil plains region of central-west Queensland in October 1996. During the afternoon of October 10 and the morning of October 11 we were able to make a series of observations on *P.brevis* as we travelled along the Landsborough Hwy between Longreach (144°15'E, 23°26'S) and McKinlay (141°17'E, 21°17'S), passing through the towns of Morella (143°52'E, 22°58'S), Winton (143°03'E, 22°23'S) and Kynuna (141°55'E, 21°35'S) along the way.

OBSERVATIONS

A total of 14 *P.brevis* were sighted and of these nine were captured. Locality data and the circumstances, conditions, etc. surrounding the sightings of each lizard are presented in Table 1. Measurements and descriptions of seven of these lizards were taken and data are presented in Table 2. Measurements were performed with a rigid 500mm ruler (accurate to 1mm), vernier calliper (accurate to 0.02mm) and spring balance (accurate to 2g).

Table 1 **Locality data and observations relating to each of the *Pogona brevis* sightings. Quoted temperatures refer to air temperatures in the shade, RH denotes the relative humidity and time is EST. Locality data are given relative to the Winton township (143°03'E, 22°23'S).**

No.	Date-Time	Conditions	Location
1	10/10/96- 4:56pm	Full sun 37.4°C; RH 31% Prostrate on bitumen surface. Adult.	77.5km SE of Winton QLD, Landsborough Hwy.
2	- 5:03pm	Full sun 37.0°C; RH 31% Basking on rock 15m from road. Adult.	69.2km SE of Winton QLD, Landsborough Hwy
3	- 5:09pm	Full sun 37.0°C; RH 31% Basking on rock 10m from road. Adult.	62.1km SE of Winton QLD, Landsborough Hwy.
4	- 5:16pm	Full sun 37.2°C; RH 31% Basking on rock 20m from road. Adult.	53.5km SE of Winton QLD, Landsborough Hwy
5	- 5:20pm	Full sun 37.0°C; RH 31% Basking on rock 15m from road. Adult.	50.2km SE of Winton QLD, Landsborough Hwy
6	- 5:51pm	Full sun 37.0°C; RH 31% Basking on rock 15m from road. Adult.	13.0km SE of Winton QLD, Landsborough Hwy.
7	- 6.42pm	Roadkill approx. 1 week old. Adult.	47km NW of Winton QLD, Landsborough Hwy.
8	11/10/96- 9.42am	Overcast 29°C; RH 42% Perched on rock 15m from road. Ground temp 42.3° Adult.	52.4km NW of Winton QLD, Landsborough Hwy.
9	- 10.01am	Partial sun 30.1°C; RH 38% Perched on rock; retreated down natural crevice. Adult.	54.2km NW of Winton QLD, Landsborough Hwy.
10	- 10.27am	Full sun 31.8°C; RH 37% Basking on rock; retreated down natural crevice next to rock. Adult.	62.3km NW of Winton QLD, Landsborough Hwy.
11	- 10.36am	Full sun 35.0°C; RH 32% Basking on rock; retreated down natural crevice next to rock. Adult.	66.1km NW of Winton QLD, Landsborough Hwy.
12	- 10.39am	Full sun 35.0°C; RH 32% Basking on rock; attempted to retreat down natural crevice 0.5 m from rock. Rock surface temp 37.4°C. Adult.	68.0km NW of Winton QLD, Landsborough Hwy.
13	- 11.34am	Full sun 36.8°C; RH 31% Propped against small shrub on road edge. Adult.	111.9km NW of Winton QLD, Landsborough Hwy.
14	- 12.28pm	Full sun 38.9°C; RH 31% Perched on a vertical branch of dead shrub; attempted to retreat down burrow. Adult.	170.6km NW of Winton QLD, Landsborough Hwy.

Habitat

The black-soil plains of the region are sparsely vegetated. The tree-layer is entirely lacking and shrubs where they occur are sparse. While the region is known to support various grasses (notably Mitchell Grass, *Astrebla* sp.) at the time of our visit the area was in drought and these were almost entirely lacking, leaving the soil exposed. The soil is dark brown in colour, crumbling and friable (to the extent that one leaves distinct indentations walking on it). They form numerous deep cracks and labyrinthine cavities. The roadside strip (10-30m wide strip between the road edge and fence) was almost entirely devoid of vegetation (see Figure 1). Small rounded rocks (<0.5m diameter) were common in the strip but are generally uncommon beyond the fence line suggesting that they were excavated during road construction. Wooden fence posts were typically quite narrow (<10cm) and of uniform size and shape.

Size & Description

Length measurements of seven *P.brevis* are given in Table 2. Witten (1994a) records mature adult *P.brevis* as having the following average SVLs: Males- SVL=128mm (range 91-148mm, n=5) and Females- SVL=130.8mm (range 122-138mm, n=3). Most of the females in Table 2 fall outside this range; the significance of this is not clear. The species may be smaller in the Winton area or drought conditions may have prevented full adult size being attained. By comparison measurements of 'breeding' adults in de Vosjoli & Mailloux (1993, p.47, n=?) exhibited the following ranges: Males- SVL=124-146mm, Total L. 254-305mm and Females- SVL=127-152mm, Total L 230-286mm. All but one of the SVL measurements given in Table 2 lie outside the combined SVL range 124-152mm, however all except one specimen (#13, with a truncated tail) had total lengths (SVL+TL) within their stated range. Ehmann (1992) gives head & body length 'to 13cm' and a total length of 25cm consistent with above. In Shea (1995) holotype measurements of *P.henrylawsoni* were SVL=126mm, TL=116mm and measurements of several Australian Museum specimens are given as SVL=120, 117mm. In Table 2 all specimens in which the tail was complete, TL exceeded SVL and this was also noted by Witten (1994a). None of the other specimens observed were substantially larger or smaller than those in Table 2. No specimens which could be classed as 'subadult' or 'juvenile' were seen. We were unable to locate any published data on the mass of adult *P.brevis* for comparison with our data.

A general colour and pattern description is based on the nine captured lizards. Specimens were all grey-brown dorsally with five or six pale grey paravertebral blotches, which in some individuals coalesce on the midline. The tail has between 13-19 dark brown bands, which may be either distinct or indistinct. Some had a dark pinkish-brown flush on the gular region. Ventral surface was white with a grey-brown variegated pattern. The buccal cavity was lemon yellow to orange, with the tongue usually bright orange (see Wells & Wellington 1985). Iris colour was typically gold sometimes with a red-brown infusion. As with other *Pogona* species, *P.brevis* is capable of marked, rapid colour changes. This was particularly evident in specimen #13 whose ventral surface changed from clean white to having a conspicuous superposed grey-brown variegated pattern within 5 minutes of capture; the gular region was also initially white and turned grey in this time. Specimens #1, 2 and 3 were dorsally yellow-brown on capture; by the next morning they were a drab grey-brown. Preanal pores numbered two (1L:1R) in all specimens while femoral pores numbered either four (2L:2R, n=5) or six (3L:3R; n=4). These fall within the stated range of 6-12 (mean 8.18) in Witten (1994a).

Sexing *P.brevis* proved difficult and the sexes assigned to individuals in Table 2 are tentative. None of the lizards examined had palpable eggs or enlarged ova. Wells & Wellington (1985) report ovigerous females in January while northern hemisphere captives oviposit from March to June (de Vosjoli & Mailloux 1993). There were no obvious post-anal pouches indicating the presence of swollen hemipenes in males. None of the

specimens had the appearance of having recently deposited eggs (e.g., 'hollow' abdominal region) and the mass of individuals was fairly consistent (Table 2).

P.vitticeps is known to occur sympatrically with *P.brevis* in the Aramac region (Witten, pers.comm.) though we did not observe any lizards fitting the description of the former. *P.brevis* is distinguished from *P.vitticeps* and other *Pogona* by its relatively short tail and limbs, fewer lamellae under the fourth toe and fewer preanal and femoral glands (Witten 1994a); the specimens we observed were entirely consistent with these criteria. In captivity the two species are known to hybridise (Rybak 1996). The size details of a small number of adult hybrid specimens (n=5) are given in Rybak (1996) however meristic characters were not provided. All SVL measurements lie outside the range of Witten (1995a) being larger (ave SVL=147mm combining male and female measurements); the TL measurements also lie outside the range obtained by pooling all data for intact tails (116-141mm vs 146-216mm) and are also relatively larger (113 vs 128% of SVL). The same is also true of mass measurements with our average of 73g compared with 159g (130-205g) for hybrids. All specimens we examined were in excellent condition and none underweight for their size. It therefore seems unlikely that the observed two-fold difference in average mass could be attributed to captive conditioning alone, but also to their larger size.

General Activity & Behaviour

Most *P.brevis* were observed conspicuously perched either on rocks (n=10) or branches (n=1, perched 0.4m from ground). The remainder were basking on the bitumen road (n=2, including the roadkill specimen) and one was propped almost vertically against a small (0.15m tall) heavy grazed shrub on the edge of the bitumen. No specimens were observed to use fence posts as perches. All exhibited postures consistent with them basking before being disturbed by us, typically with the dorsal surface expanded and either oriented towards the sun or adpressed against rocks. Specimens #13 and 14 had their bodies vertical, no expanded dorsum with their white chest oriented towards the sun. Air temperatures when specimens were observed ranged from 29.0°C to 37.4°C while the relative humidity ranged from 31% to 42% but tended towards the lower end (mode 31%).

In the course of being captured we observed *P.brevis* employ several kinds of behaviours in order to avoid detection and to avoid capture once detected:

(i) *crypsis*- on being approached some individuals would crouch down, lowering the head and body so that it lay flat against the substrate (rock, ground surface, soil or bitumen) while remaining completely still, carefully watching our approach. Three individuals were easily captured by hand after employing this cryptic posture. Another individual, when flushed out onto exposed soil, adopted the cryptic posture and allowed us to approach to within 0.5m. They are able to blend very effectively in with the soil substrate; this along with the cryptic posture are indicated in Figure 2.

(ii) *retreat*- on being approached some individuals would dismount their perches (rocks or branches) and attempt to conceal themselves. Four individuals basking on rocks simply dismounted and hid behind the basking rock, where they crouched up against the base, still clearly visible since there was no surrounding vegetation. Two individuals were observed to retreat down burrows or deep soil crevices. One of these initially attempted to conceal itself in amongst a dead shrub and on being flushed out ran some 12m across open ground into a burrow. Three lizards attempted to retreat down natural crevices located within 1m of their basking site, two lizards down a burrow one <1m away and the other 12m away. The width of natural crevices utilised was no smaller than 20mm. One individual could be seen poised vertically 0.3m below the soil surface down a crevice which was at least 0.6m deep. We noticed

that lizards were capable of detecting our approach (by retreating) up to 30m away. Ehmann (1992) states that "When alarmed, it scurries into a wide soil crack or an associated burrow, usually under a rock or fallen timber." (p.138).

(iii) *threat display*- when approached by us all lizards adopted behaviour (i) and (ii). However on being restrained or cornered it was not uncommon for individuals to expand their dorsal surface, gape their mouth and erect their rather small 'beard' in a similar manner to *P.barbatus*. Several individuals were observed when threatened to jump small vertical distances (<10cm) in attempts to bite objects overhead.

External Parasites

On one individual (#12, Table 1) small patches of orange mite were visible on the gular region and a skin fold on the head. No other external parasites were visible.

DISCUSSION

The fact that we saw no *P.brevis* perched on fence posts agrees with Witten (1994a) who states "The two specimens I collected were on a dirt road in black soil country. Despite spending several months in the Aramac area I never saw *Pogona* of this *[P.brevis]* size perching on fence posts". Witten (1994a) continues: "It is possible that *P.brevis* defends territory without the normal perching behaviour of other *Pogona*. Almost half the other specimens in museum collections were road kills, also suggesting the species is not obvious to passing herpetologists." Our observations run counter to the latter statement as we found the species to be conspicuous when perched on roadside rocks while travelling through the Winton region by motor vehicle at 70-80km/h. The ease with which lizards are detected on roadside rocks would depend much on the surrounding vegetation cover. Our observations were made easy by the lack of any substantial vegetation cover; at other times of the year these areas are known to support stands of tussock grass which would make passing observation of *P.brevis* difficult.

It is notable that only adult *P.brevis* were seen, indicating perhaps that juveniles constitute a relatively small proportion of the population or else do not utilise perching sites as adults do. While it may be argued that this was due to observer bias, in that juveniles would be more difficult to detect due to their small size, this explanation cannot account for the fact that we were readily able to spot adult *Tympanocryptis lineata lineata* (SVL=60mm, Wilson & Knowles 1988) in the same areas. The absence of juveniles might also indicate rapid growth with adult size being attained in less than 12 months of age. Predators, in particular feral cats, are known to prey on this species (G. Witten, pers.comm.) and might also account for the lack of juveniles.

It would be of interest to know how frequently the species occurs beyond the roadside strip where rocks tend to be less numerous. That the artificially created roadside habitat (i.e., the displaced rocks) is utilised by *P.brevis* is interesting in itself for it might predispose them to higher mortality by road vehicles and also may indicate a preference for similar areas away from roads.

It is evident from this work that there exist many gaps in the basic ecology of *P.brevis* within its natural range. There currently appears to be no information on the species natural diet, predators, growth (although see Witten (1994b) for information on relative growth in captive specimens), population structure and little information on the timing of reproductive events. It is hoped that this work will stimulate enquires into these various aspects.

ACKNOWLEDGEMENTS

We wish to thank Dr. Geoff Witten for his helpful discussions, improvements to the manuscript and for providing us with several references. We also thank the referees for alerting us to the earlier usage of the name *A.rankini* and making available private correspondence on the subject.

Table 2 Data on seven of the *Pogona brevis*

No.	SVL MM	TL MM	HL MM	HW MM	MASS GR	SEX
1	118	129	30	28	62	M
2	116	133	31	29	70	F
3	120	128	31	28	70	F
9	117	137	33	29	78	F
12	117	139	31	29	80	F
13	138	107*	33	30	70	F
14	123	94**	32	28	78	M
AVE	121.3	133.2	31.6	28.7	72.6	

* ESTIMATED 20-30MM MISSING
** ESTIMATED 30-40MM MISSING
Note that the TL measurements of #13,14 are excluded from the calculation of the average TL value.

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Figure 1 Sparsely vegetated roadside strip with small rocks and cracking clay soils beside the Landsborough Hwy, 52km north-west of Winton, Qld. - habitat of *Pogona brevis*. Specimen#8 (Table 1) was located in the foreground of the picture. (Photo: R. Valentic).

Figure 2 Cryptic posture adopted by *Pogona brevis* specimen #4, (Table 1) lying on cracked 'black' clay substrate. Note the crouched position with the eye intent on the perceived danger and the background colour matching. (Photo: G.Turner).

PREDATION OF A MARSUPIAL CARNIVORE BY AN OLIVE PYTHON (*LIASIS OLIVACEUS*) AND A KING BROWN SNAKE (*PSEUDECHIS AUSTRALIS*).

Meri Oakwood[1] and Gregory L. Miles[2]
[1]Division of Botany and Zoology, Australian National University, Canberra ACT 0200 and [2] Parks Australia North, Kakadu National Park, PO Box 71, Jabiru NT 0886

Due to the relative infertility of Australia and consequent lack of small mammal abundance, the majority of Australian snakes, in particular elapids, concentrate on reptiles as their main source of prey (Shine 1991). King Brown snakes conform to this pattern with only 23% of their diet composed of mammals. In contrast, mammals are the most important component of the diets of most Australian pythons (Slip and Shine 1988). Olive pythons have 48% of their diet composed of mammals (Shine 1991). Described below are two records of snake predation on a carnivorous marsupial, the Northern quoll (*Dasyurus hallucatus*).

The Northern quoll is a nocturnal hunter (weighing up to 1200g) with a "pugnacious disposition"' (Fleay 1962) that preys upon snakes, lizards, frogs, birds, mammals, and invertebrates including venomous species such as centipedes (Oakwood 1997). It is also considered to be relatively unpalatable, early this century the Aboriginal people of north east ArnhemLand called it "buggan tumuro" which meant smelly flesh (Dixon and Huxley 1985). Dingoes tend to kill Northern quolls but not consume them (Oakwood 1997). Yet despite its aggressive reputation and apparent unpalatability, two incidents of consumption by snakes were recorded during a two year radio-tracking study of quolls.

Both incidents occurred at Kapalga Research Station (12°43'S, 132°26"E) in Kakadu National Park, Northern Territory. The first occurred on the 7th June 1993, when an adult male quoll that had weighed 770g when trapped three days earlier was being radio-tracked. The radio-signal led to a satiated 2.6m long Olive python (*Liasis olivaceus*) resting in a hollow termite mound in eucalypt woodland. The mound was approximately 1.2m high and 1m diameter and had been constructed by the tree piping termites *Coptotermes acinaciformis*. Although Northern quolls are known to use termite mounds for dens, it was not possible to determine whether the quoll had been captured in the termite mound, or whilst foraging. Olive pythons are likely to be largely ambush hunters as are Diamond and Carpet pythons, *Morelia spilota* (Slip and Shine 1988; Shine and Fitzgerald 1996). Although for most of the year, quolls use different dens every day, many other species of vertebrates use termite mounds for shelter or nests (Braithwaite 1990). Termite mounds with enclosed hollows are rare, thus they could be a productive ambush site. The python stayed in the mound for 9 days and on the 10th day was located lying about 2m away from it. It was then taken into captivity to ensure that it managed to excrete the transmitter. In captivity, the python began to exhibit signs of discomfort (not coiling tightly, open mouth) and consequently was transported 200km to the nearest place where it could receive veterinary attention (Darwin). An X-ray showed that the radio-transmitter appeared to be caught within the intestine (Fig. 1). The whip antenna was pointing cranially so it was unlikely to have prevented the continued passage through the gut, but may have prevented regurgitation. Diamond pythons (*M. spilota*) that had consumed Common Ringtail possums (*Pseudocheirus peregrinus*) wearing radio-transmitters with the antenna encapsulated around the collar, have been observed to regurgitate the packages rather than pass them through their intestinal tract, although one python required surgery (B. Smith pers. comm.). Perhaps the intestinal tract of snakes

may be too narrow to accommodate the indigestible packages. The Olive python underwent surgery to remove the collar and transmitter. It was treated with intra-peritoneal fluids, antibiotics and vitamins during recovery and kept under observation. Two weeks later it was returned to Kapalga where it was re-released on the 11th July near the same termite mound.

The second incident of quoll predation by a snake was discovered on the morning of the 9th November 1993 when a 450g adult female quoll was being radio-tracked. November is late dry season in the wet-dry tropics and most of the area had been burnt during the previous three months resulting in little ground cover. Her radio-signal led to 1.6m King Brown snake (*Pseudechis australis*) in a strip of thick unbumt grass along a damper creekline (although the creek was dry) in open eucalypt forest. King Browns actively search for prey and this individual probably caught the quoll when she was foraging at night. That afternoon, the King Brown was tracked to a hole in the ground below the thick grass about 100m further along the creekline. This snake was also captured (which required digging it up) for observation. Unfortunately, while in transit to the veterinarian, the King Brown asphyxiated after regurgitating the quoll. The transmitter remained caught inside the gut.

The only other known record of a snake consuming a Northern quoll was an Amethystine python (*Morelia amethystina*) at the Cape York Wilderness Lodge in far north Queensland (Low 1989). This python species, which feeds exclusively on mammals (Shine 1991), has also been recorded coiled around a trap containing a Northern quoll in the Lamb Range near Cairns (L. Pope pers. comm.).

There are now three species of snake recorded to have consumed the aggressive and relatively unpalatable Northern quoll. Since snakes use chemoreception to detect prey (in addition to pythons' use of infra-red, Shine 1991), perhaps the strong distinctive odour of Northern quolls, combined with their use of scent marking (including rubbing scent glands on objects and depositing faeces in prominent places) increases the ease with which their scent trails are followed by snakes.

ACKNOWLEDGMENTS

We wish to thank D. Atkins (Parap Veterinary Clinic) for his efforts in recovering the radio-transmitter, post-operative care of the python and providing the X-ray. R. Eager (CSIRO) re-released the python at the site of capture. D. Atkins, G. Bedford, R. Eager and B. Smith reviewed the manuscript.

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Figure 1 X-ray photograph showing radio-transmitter with whip antenna inside Olive python. (D. Atkins)

FIRST RECORD OF THE SCINCID LIZARD *CTENOTUS ARCANUS* FROM NEW SOUTH WALES

Michael J. Murphy
NSW National Parks and Wildlife Service
Northern Zone Office, PO Box 914 Coffs Harbour NSW 2450

Continuing taxonomic research into Australia's herpetofauna has resulted in the description of 340 new species since 1975 (Cogger 1996). Knowledge of the distribution and ecology of many species is incomplete.

The *scincid* lizard *Ctenotus arcanus* was described in 1982 from 12 specimens from coastal south-eastern Queensland (Czechura and Wombey 1982). The species was reported to occur in open eucalypt forest, woodland and rocky outcrops, from Fraser Island and Bundaberg in the north to Mt Tamborine in the south, extending inland as far as the coastal ranges (Czechura and Wombey 1982). *C. arcanus* was listed by Czechura and Covacevich (1985) as a species of indeterminate risk in Queensland, because of its patchy distribution in an area of high human impact; however, the species is classed as common in the Queensland *Nature Conservation (Wildlife) Regulation* 1994.

The purpose of this paper is to document the recent discovery of *C. arcanus* at Bundjalung National Park (29°21'S 153°18'E) in north-eastern NSW. This record extends the known range of the species by approximately 160 km, and is the first record of the species in NSW.

The site at which *C. arcanus* was recorded is located about 3.5 km from the coast, and 2.5 km east of the village of Woombah, in the southern part of Bundjalung National Park (Fig. 1). The elevation is less than 10 m AHD. The vegetation of the general area is open forest and low coastal heathland.

The observations documented in this paper were from a confined area approximately 30 m by 20 m. The site (Fig. 2) had a sandy substratum and a cover of coastal heath to 1 m height. Plant species present included *Acacia ulicifolia, Styphelia viridis, Homoranthus virgatus, Caustis recurvata, Ricinocarpos pinifolius, Dillwynia retorta, Leucopogon* sp. and *Pteridium esculentum*. The site was adjacent to open forest dominated by *Corymbia gummifera, Eucalyptus pilularis* and *Banksia serrata*. More than 100 sheets of iron from a previously existing building were lying scattered over the site.

A single specimen of *C. arcanus* was found sheltering under a sheet of iron at the site in February 1997, and was photographed (Fig. 3) and released. It was distinguishable from *Ctenotus taeniolatus* by the presence of spots in the body pattern, from *Ctenotus robustus* by the black upper lateral zone containing distinct white spots, and from *Ctenotus eurydice* by the continuation of the upper lateral spots posteriorly.

The specimen closely resembled both the *C. arcanus* paratype specimen QMJ38695 figured by Czechura and Wombey (1982), and the *C. arcanus* specimen figured by Ehmann (1992). The identification of the specimen as *C. arcanus* was confirmed by G. Czechura and S. Wilson of the Queensland Museum following examination of the photographs (Czechura pers. comm.).

The site was searched again on two days in May 1997, two days in September 1997 and one day in February 1998 (each visit involving about 1 hr search effort), but no further specimens of *C. arcanus* were found. Species of herpetofauna found at the site during the six visits are listed in Table 1.

C. arcanus was previously known from a restricted range in south- east Queensland, estimated at betweeen 10,000 and 30,000km^2

Table 1
Species recorded at the study site in Bundjalung National Park, NSW.

Scincidae
- *Ctenotus arcanus*
- *Ctenotus robustus*
- *Ctenotus taeniolatus*
- *Lampropholis delicata*

Elapidae
- *Demansia psammophis*
- *Rhinoplocephalus nigrescens*

(Ehmann 1992). The discovery of the species in Bundjalung National Park in NSW is a significant extension of the known range. Further field work in north-eastern NSW is needed to determine whether this population is continuous with, or disjunct from, the south- east Queensland population, and to clarify the conservation status of the species in NSW.

ACKNOWLEDGEMENTS

Thanks to Greg Czechura, Ross Sadlier and Steve Wilson for assistance confirming the *C. arcanus* record, and Paul Sheringham for identifying heath flora species at the site.

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Figure 1 **Location where *Ctenotus arcanus* was found in the southern part of Bundjalung National Park, NSW.**

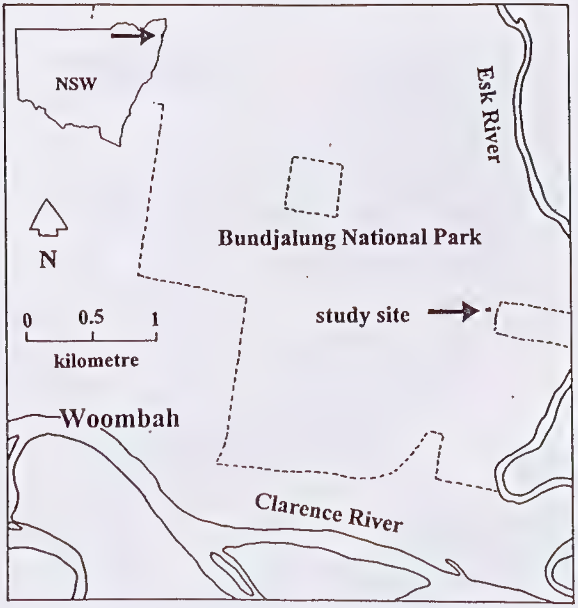

Figure 2 *Ctenotus arcanus* site in Bundjalung National Park,NSW. Photograph by Michael Murphy

Figure 3 *Ctenotus arcanus* from Bundjalung National Park,NSW. Photograph by Sue Elks.

RECOGNITION OF TWIN NEONATES IN A GREEN PYTHON *MORELIA VIRIDIS* (SCHLEGEL, 1872) CLUTCH.

Brian Mackness
School of Biological Sciences,University of New South Wales, NSW, Australia, 2052
Frank Bambang Yuwono
C.V. Terraria Indonesia, Jalan Kepodang, Raya Blok K4/24,
Bintaro Jaya - Sektor 2, Jakarta Selatan, Indonesia
Trooper Walsh
Department of Herpetology, National Zoological Park, Washington, DC, 20008, USA

The green python *Morelia viridis* (Schlegel, 1872) is found in the tropical forests of Cape York Peninsula, Queensland (Cogger et al. 1983) as well as in New Guinea and Indonesia (McDowell 1975). Reports of *M viridis* from the Solomon Islands by Burt & Burt (1932) and by MacCoy (pers. comm. cited in McDowell 1975) have yet to be confirmed and are considered doubtful (McDowell 1975). Throughout its range, the green python exhibits a wide range of colour variation with several colour morphs being identified from geographically isolated populations (e.g. Biak Island and Aru Islands) (Zenneck 1898; Thomson 1935; McDowell 1975). Juvenile green pythons likewise exhibit a range of colour variation ranging from brick red to bright yellow (Lönnberg 1900; Sternfeld 1913; Gilliard 1953; McDowell 1975). The moulting patterns of certain wild green python populations may also be distinctive and are currently under study by two of the authors (BM & FY).

Green pythons have been bred in captivity over many years and a large amount of data is now available on their care and husbandry (Blake 1992; Van Mierop *et al.* 1982; Walsh 1977, 1979, 1981, 1994 and Zulich 1984, 1990).

Twin births in green pythons are uncommon but have been recorded by one of us (TW) in previous years. In 1991, twin green pythons were produced at the National Zoological Park, USA from a second generation captive bred male of unknown provenance and a wild caught female from Biak Island, Indonesia. The twins had a mass of 3.0 gms and 2.9 gms respectively in a clutch with a mass range of 9.1 gms - 11. 4 gms.

A second set of twins were hatched in a private facility from a first generation captive bred male of Tulsa Zoo stock (unknown provenance) and a second generation captive bred female of Al Zulich stock (unknown provenance). Upon hatching, the twins had a mass of 3.1 gms and 3.7 gms respectively in a clutch with a mass range of 5.7 gms to 11. 7 gms.

On 28 September 1995, a captive female green python laid 13 eggs at the breeding facility of C.V. Terraria Indonesia, Jakarta. The female, captured some time previously from the wild from Kepulauan Aru, Indonesia (6°00'S 134°30'E), had a snout-vent length of 123cm and a total length of 140cm. The eggs were incubated by the female in a plastic container and all hatched on 17 November 1995, after an incubation period of 50 days. The young were transferred to a larger container at which stage 14 individuals were counted, indicating that a twin birth had occurred. The neonates were measured with their mass taken in an effort to determine the identity of the twins. The two smallest young (CTV/ 13,14) were examined and found to have very similar markings on the head further suggesting that they were indeed the twin neonates.

Neonatal green pythons have structurally undifferentiated head scales except in the eye and nasal regions. Those from Kepulauan

Aru, are mostly bright yellow with a series of brown and white markings over the entire body (Yuwono, unpublished data). These markings do not correspond with underlying scales and the comers of several scales may make up one patch of colour. For example one half of the scale may be white, while the other half being part of its brown border. While examining the neonates, it became apparent that each animal had a distinctive set of markings on its head and this could facilitate its identification (Fig. 1). Three groupings of head markings that were apparent on all of the neonates were chosen for investigation and classified as 1) the parietal bar; 2) the fronto-parietal arches and 3) orbital patches. A further distinctive marking, labelled the occipital stripe, was noted but not used because it became obscured when the young retracted their heads against their bodies.

PARIETAL BAR

This was the most distinctive marking stretching as a band of brown and white spots, often irregular in shape, across the widest, posterior aspect of the head. The band was continuous and could be straight but in most specimens, curved downwards and posteriorly. Only one of the thirteen juveniles, (CTV/ 1) had a break in this band although in others (CTV/2, 10) the band was often constricted in the middle to such an extent that the parietal bar was only a thin line of brown colouring or a few tiny coloured scales. In the neonates (CTV/13,14) this band provided the most reliable method of identification as it was almost identical in both animals.

FRONTO-PARIETAL ARCHES

These colour markings normally consisted of two laterally opposing arches positioned near the crown of the head. These were highly variable and often linked to either the parietal bar (CTV/6) or the orbital patches (CTV/2). In the twin neonates (CTV/13,14), and in (CTV/ 12), these fronto-parietal arches were reduced to small patches. Twin (CTV/ 13) had a curved left arch and a smaller cluster on the right hand side. Twin (CTV/14) had two patches roughly the same size and shape. Many of the fronto-parietal arches did not mirror each other with one side being straight, the other arched (CTV/8).

ORBITAL PATCHES

These colour markings consisted of patches and lines in the supraorbital region. In (CTV/2) a line of brown edged white scales joined with those of the fronto-parietal arch to form a broken cross on the head. In twin (CTV/13) these patches were a long and short diagonal line. In twin (CTV/14) the left hand line was broken and the right hand side line reduced to a small patch.

DISCUSSION

The colour in the skins of reptiles is determined by chromatophores located in the uppermost layer of the dermis (Bagnara & Hadley 1973). The three general chromatophore types (xanthophores, iridophores and melanophores) act either singly or in aggregate to generate overall skin colour (Morrison *et al.* 1995). The identification of twin neonates in a green python clutch using head patterns suggests a genetic link to some aspects of colouration. As neonate green pythons moult, differences in head patterns become more and more obfuscated as various hormonal and ecological factors come into play. The distinctive head markings gradually disappear.

The identification of individuals using head patterns is a useful tool in ontogenetic studies, negating the need for marking and/or segregating the animals. Walsh (1994) has demonstrated a link between overhandling and a condition in captive-raised green pythons known as "kinky-tail syndrome". Although the Aru Islands twins had less mass and were shorter than all other siblings in the clutch at birth, identification by this means was not satisfactory in the long term, given the potential for disparate rates of growth

amongst the siblings as well as the increased chance of stress and mortality through over-handling. The apparent existence of several geographically distinct colour morphs and patterns of moult amongst green pythons may be linked to the genetics of individual populations and this is currently under investigation by the authors through genetic and breeding studies.

ACKNOWLEDGMENTS

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Table 1

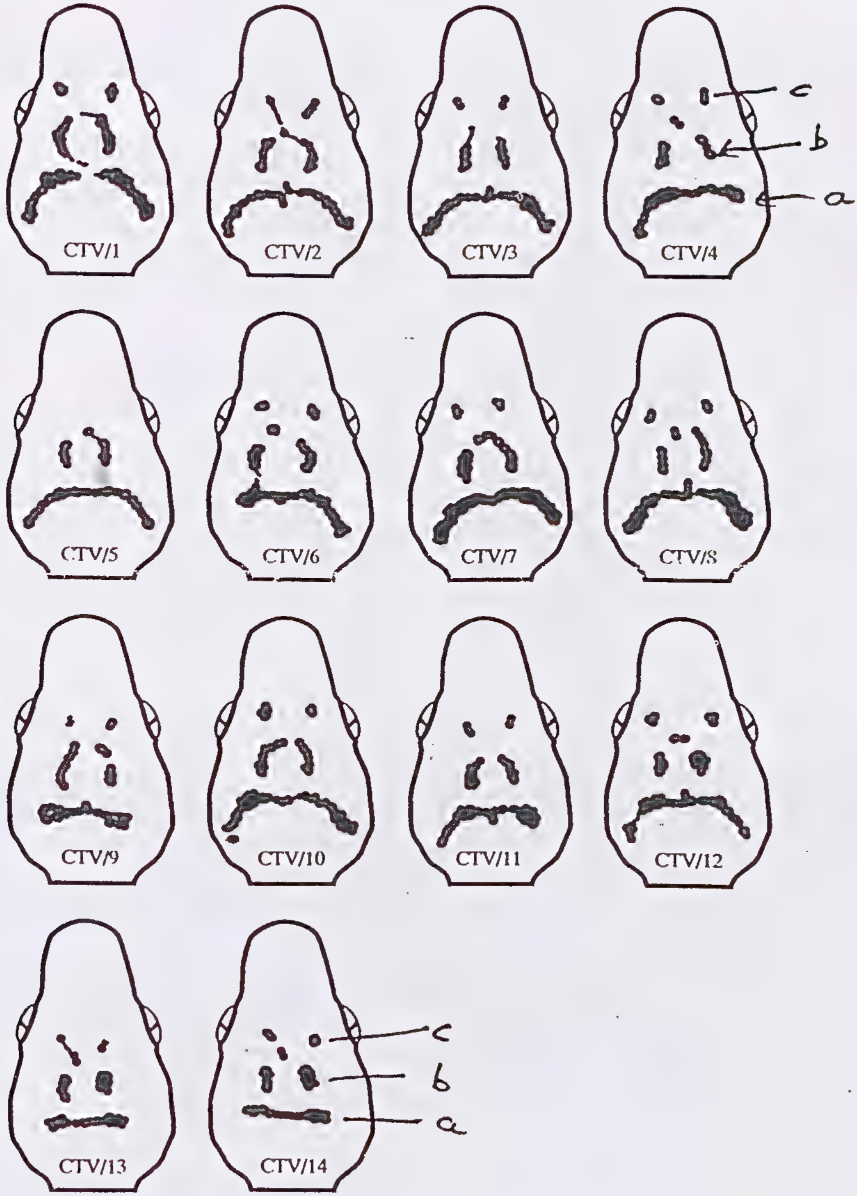
Measurements of mass and body size of 13 neonate green pythons

Specimen	Mass(g)	SVL (mm)	TL (mm)
CTV/1	10	27	33
CTV/2	9	25	31
CTV/3	10	27	33
CTV/4	10	27	32
CTV/5	11	30	35
CTV/6	10	29	32
CTV/7	11	30	35
CTV/8	11	29	34
CTV/9	10	30	35
CTV/10	11	30	35
CTV/11	10	29	33.5
CTV/12	11	30.5	35.5
CTV/13*	6	24	26
CTV/14*	6	21	25

* twin

Figure 1

Individual head patterns of 14 green python neonates.
a) parietal bar;
b) fronto-parietal arches;
c) orbital patches.



A SIZE RECORD AND FURTHER DISTRIBUTIONAL DATA FOR *SUTA DWYERI* (ELAPIDAE) IN THE SYDNEY BASIN

Rob Valentic, 11 Mulgowrie Court, Greensborough, Vic 3088

INTRODUCTION

Ehmann (1992) gives a maximum total length of 540mm for *Suta dwyeri* and states that specimens from more eastern rocky areas are usually slender to strong bodied in comparison to specimens associated with the inland drainages west of the dividing range. The largest specimen recorded to date in the literature is a male from Queensland (Qld) with a snout - vent length (SVL) of 456mm (Shine, 1988;1994). Shine (1988) presents a table showing a sexual size dimorphism in favour of males in the species with a SVL range of 233 - 456mm for males and 235 - 345 mm for females (NSW and Qld specimens combined). Coventry and Robertson (1991) give a total length of 600mm presumably for Victorian specimens of *S. dwyeri* and *S. nigriceps* although it was not established whether these are formal measurements or only estimates. Both Cogger (1992) and Wilson and Knowles (1988) give total lengths of 400mm for *S. dwyeri*. The following note provides details of an adult male *S. dwyeri* from the Putty Road within the Sydney Basin exceeding the maximum SVL recorded by Shine (1988) and possessing an extremely robust build.

OBSERVATION

Date: 1st March 1997.

Time: 21.22hrs (Eastern Standard Time/ Daylight Savings Time).

Weather Conditions: Fine with no moon and a gentle breeze. Air Temp: 25°C. Relative Humidity: 76% (Measurements taken with a Smart Digital Thermo - Hygrometer).

Location: Colo Heights, New South Wales (Lat: 33°23'S. Long: 150°45'E.).

Habitat: Sandstone ridge vegetated predominately with eucalypts and with a *Themeda* sp. understory.

Notes: A snake was spotted loosely coiled on the middle of the Putty Road roughly 100 metres south of the Service Station and was identified as a male *S. dwyeri*. Head measurements were taken using a set of Mitutoyo Digimatic Callipers and weight obtained using a set of Ohaus Cent -o- Gram scales (0-311 grams, d = 0.01 gram). The snake probed to a depth of seven subcaudals and weighed at 53.97 grams. The following measurements were taken: SVL: 486mm. Tail Length: 72mm. Total Length: 558mm. Head Length: 21.4mm (taken from the anterior edge of the rostral scale to the posterior edge of the parietals). Head Width: 11.8mm. There were 15 mid - body scales, 33 single subcaudals, single anal scale and 154 ventrals (all single). The specimen was considerably darker dorsally and was more robust in build with a bulbous head in comparison to inland specimens from Nyngan, NSW (Lat: 31°34'S Long: 147°12'E) and Bendigo, Victoria (Lat: 36°46'S Long: 144°17E) that I have examined. The snake was photographed (figure 1) on a nearby rock and then released.

DISCUSSION

S. dwyeri is usually associated with granite outcrops on the drier western slopes of the ranges and is typically discovered beneath rock exfoliations in both NSW and Victoria (pers. obs.). Swan (1990) and Wilson and Knowles (1988) noted that the species extends into the Hunter Valley and Swan lists two locations on the upper Hawksbury drainages where the species has been found. Shea (1994) highlighted some of the pre-

dominately arid or western slopes species that enter the northern Sydney Basin through the Hunter Valley corridor, and *S. dwyeri* is yet another example. This species was not included in Griffiths (1987) but is in Griffiths (1997). Anthony Stimson, a resident of Colo Heights has never seen the species in the area although Richard Wells has confirmed the presence of *S. dwyeri* in the region (R. Wells, pers. comm.).

ACKNOWLEDGEMENTS

Thanks to Anthony Stimson for his hospitality during my visit to Sydney and to Grant Turner for his help in locating the Shine references and critically reading a draft manuscript.

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Figure 1 *Suta dwyeri* from the Sydney Basin.

RECENT RECORDS OF THE GIANT BURROWING FROG (*HELEIOPORUS AUSTRALIACUS*) FROM THE FAR SOUTH COAST OF NSW

Francis Lemckert[1], Traecey Brassil[1] and Ken McCray[2]
1. Research Division, State Forests of NSW. PO Box 100 Beecroft NSW 2119
2. Eden District Office, State Forests of NSW. Eden, NSW

INTRODUCTION

The giant burrowing frog, *Heleioporus australiacus*, is a large (up to 90mm) and robust, myobatrachid frog found in forests of south-eastern Australia from the east Gippsland area of Victoria to the sandstone areas just north of Sydney (Cogger, 1992). Its preferred habitats are noted to be dry forest and heathland (Daly, 1996) although Littlejohn and Martin (1967), Gillespie (1990) and Recsei (1996) provide a few records of this species from wetter forests. Males are reported to call from burrows in the sides of streams (Barker et al, 1995), but little is known of the habits of females. Gillespie (1990) noted an apparent natural disjunction in the range of this species between Jervis Bay and Bega, a gap which was narrowed by Daly (1996) who considers it likely that there is no disjunction. This frog appears to be found through a range of native vegetation types, but is not known from cleared lands (Gillespie, 1990; Lemckert, pers. obs.). The giant burrowing frog is known predominantly from sandstone areas in the northern part of this species' range, but more utilises granitic based soils in the south (Recsei, 1996).

The giant burrowing frog has been identified as a species of concern both by the National Parks and Wildlife Service of New South Wales (listed as vulnerable under the Threatened Species Conservation Act) and by the New South Wales Frog and Tadpole Study Group (listed as at low risk, but conservation dependent; Ehmann, 1996). These listings are a result of concerns that this frog has undergone a decline in the size of its populations (Recsei, 1996). The current status of the species on the far south coast of N.S.W. is uncertain as the last documented sightings of the frog were obtained in the early 1980s (Lunney and Barker, 1986; Webb, 1987 and 1991a).

We report here on more recent sightings of this species which confirm that this frog is still present on the far south coast of N.S.W. and provide new records which confirm that there is no major geographical disjunction in this species' range. We also present information gathered from each record sites to add to our limited knowledge of the habitat requirements of this frog in southern NSW and discuss the value of various survey methods in locating this frog.

STUDY AREA

The survey area lies within south eastern New South Wales. It extends south from Narooma to near the New South Wales/Victorian border and west to the Bombala district in an area roughly bounded by 36°13′ to 37°22′ S and 149°15′ to 150°09′ E (see Figure 1). The record sites were located within state forests of the Narooma and Eden Management Area of State Forests of New South Wales (SFNSW), which are areas of predominantly coastal forest between 50 to 450 m elevation (see Table 1). The mean average rainfall is between 800 and 950 mm with the highest falls occurring from mid-summer to early winter (SFNSW, 1995).

Five broad geological groups have been described in the Management Area, but the areas recently surveyed have fallen within the major geological groups of Ordovician Metasediments (sedimentary) and Bega Batholith (igneous intrusive) (SFNSW, 1995, and Table 1).

Approximately two-thirds of the study area is

covered by dry eucalypt forest with the most widely distributed forest types being the Silvertop Ash/Stringybark league, which is found in more open areas, and the Messmate/Gum league found in the wetter gullies on the coast (SFNSW, 1995).

METHODS

The databases held in the Eden and Narooma offices of SFNSW were searched to locate records of the giant burrowing frog obtained since 1994. Local staff were then asked for further details of these sightings, particularly for exact information on locations, and these sites were then re-visited to record information on the surrounding habitat. They were also asked to provide information on the forms and extent of surveys undertaken for this species over the same period so that survey efforts could be quantified.

A total of 17 habitat variables (listed in Table 1) were recorded for each site with the variables collected being based on those developed for the ENDFROGS program by the NSW Frog and Tadpole Study Group (See Adair et al, 1994). The Australian Map Grid references (AMGs) and altitude were taken from 1:25,000 topographic maps. The habitat variables were recorded from a five square metre quadrat located 30 metres distance from the *Heleioporus autraliacus* record site in a randomly chosen direction. The presence of logging disturbance was estimated over a one hectare area where the presence of stumps or other logging debris were noted. The three dominant species of each vegetation layer were identified, where possible. The percentage foliage cover for the overstorey and understorey layers were estimated. These variables were recorded in broad categories to account for observer bias. An estimate of percentage cover was made for logs, litter, grass and other low vegetation within the five square metres.

RESULTS

The following records were made for the giant burrowing frog between Narooma and Eden between late 1994 and early 1997:-

1) Log dump adjacent to road in Broadwater State Forest (AMG 758500 5899300). On the 20th of November 1994 a single individual was located by David Coombes (Forest Research and Development Division, SFNSW) sitting on a track on a ridge top in an area of low open forest with a large heath component. Dominant overstorey species at the site are *Eucalyptus sieberi* (silvertop ash) and *Corymbia gummifera* (red bloodwood) and the understorey consists of heath species such as *Banksia serrata* (old man banksia), *Banksia spinulosa* (hill banksia) and various *Acacia sp,* (wattles). It was not raining at the time of the record, but the ground was quite wet following rains in the last 24 hours.

2) Compartment 336, Yambulla State Forest (AMG 730840 5871780). On the 11th of February 1997 the recently crushed body of a male giant burrowing frog was found on a logging track by Russell Clark and Linda Cotterill (Southern Region, SFNSW). The habitat within the compartment consists of a dry sclerophyll forest dominated by *Eucalyptus sieberi* and *Eucalyptus obliqua* (messmate gum) in both the over and understoreys. The compartment was being logged at the time and it appears that the frog was probably buried just beneath the soil and was likely crushed by a truck removing logs from the site. There was no permanent water nearby to this site on the mid-slope, but the frog was found close by to a drainage line which would flow after rainfall. Follow up surveys using call playbacks and spotlighting failed to locate further individuals at the site.

3) Junction of Yambulla and Wallaby Roads, Yambulla State Forest (AMG 725900 5872600). On the morning of the 13th of February 1997 Jim Shields (Southern Region, SFNSW) observed a single individual crossing over Wallaby Road which disappeared down a hole in a partly inundated section of vege-

tation adjacent to the road. The general vegetation within the area consisted of an open, low and dry forest dominated by *Eucalyptus sieberi* with an understorey of sapling *E. sieberi* and *Allocasuarina littoralis* (black sheoak). There had been moderate rainfalls during the previous night and there were intermittent showers at the time of observation.

4) Finch Road, Yambulla State Forest (AMG 731090 5870990). On the night of the 23rd of February a gravid female frog was located by two of the authors (FL and TB) sitting on the road. The forest is composed of a dry sclerophyll forest with an overstorey and understorey dominated by *Eucalyptus sieberi* and *E. agglomerata* (blueleaved stringybark). Notably the forest on the northern side of the road had been logged previous two weeks previously. There had been consistent rainfall that afternoon and intermittent showers occurred throughout the night. The frog must have been moving around as the road was traversed only ten minutes previously.

5) KB road, Bodalla State Forest (AMG 764300 5974100). At 8:00 AM on the 6th of March 1997 Warren Purdom (working in Narooma District, SFNSW) heard a short and then longer call of a giant burrowing frog emanate from the head of a gully adjacent to KB road. The forest surrounding this site is a dry sclerophyll with *Corymbia gummifera, Eucalyptus agglomerata* and *E. muelleriana* (yellow stringybark) as the dominant canopy trees and *Acacia terminalis* and *Persoonia species* in the understorey. Light rain had fallen on the previous night.

6) Trail in Compartment 27, Bodalla State Forest (AMG 237100 5990450). On the 5th of February 1996, a single *Heleioporus australiacus* was captured by Steve Hunt (working in Narooma District, SFNSW) after being located sitting on a track at night during a pre-logging survey of the area. The individual was a large male of 83mm in length and 150g in weight which photographed and released back to the site of capture. This is a ridgetop area with a dry sclerophyll forest dominated by *Eucalyptus muelleriana* (yellow stringybark), *E. smithii* (gully peppermint) and *E. longifolia* (woollybutt). The understorey consisted mainly of various wattle species growing in dense patches. There was also a nearby drainage line with a lilly pilly/myrtle rainforest. There had been moderate rainfalls over the previous 24 hours.

7) Under a road approximately 4km north of Bermagui in Bermagui State Forest (AMG 235300 5967650). On the 11th of September 1996 Graeme Riches (working in Narooma District, SFNSW) heard this species calling from a drain running under a road during excavation work on the roadside drainage channel. The frog called several times allowing him to clearly identify it as this species. The forest is dry sclerophyll forest dominated by *Corymbia maculata* (spotted gum) with a very open understorey.

8) The "Loop Road" off Correa Road in Murrah State Forest (763400 5952700). On the 28th of February 1996 David Coombes was performing an owl call playback on a ridge top. During the playing of a sooty owl call sequence, a *Heleioporus* male was heard calling from an area adjacent to a log dump on the ridge-top. The exact position of the calling individual could not be determined as it ceased calling before the call playback was completed. The ridge is covered in a dry sclerophyll forest dominated by *E. smithii* and *Eucalyptus sp.* (stringybark). The understorey was dominated by young eucalypts of the same species, *Allocasuarina littoralis* (black she- oak) and *Cassinia longifolia* (shiny cassinia). There had been no recent appreciable recent rainfall at the time of this record.

All records were of single adults only and all came from within a state forest. Two of the records were made when conducting surveys which targeted this species, but none of these records were the result of a "standard" survey involving the listening for the calls of this species (either unsolicited or due to call playbacks). Rather, records mostly came about as the result of individuals being observed in open areas during or after rainfall (roads or log dumps) when apparently foraging. Four

of the eight records were of individuals on (unsealed) roads running along ridge-lines indicating that this species regularly moves away from riparian sites. The majority of records were made at night, but one record was made during a morning after overnight rain.

In terms of the habitat around the record site, all frogs were found in areas of dry forest with the understorey composition being variable. Altitude, aspect, position on slope, soil type, canopy cover, understorey cover and ground-cover from the record sites are quite variable, but there may have been a preference for "older" vegetation types with only one record being obtained within a newly regenerating forest. Leaf litter depths and canopy heights at sites where the giant burrowing frog was found appeared to be relatively low which probably reflects the fact that this was dry forest. Finally, downed timber in the form of logs was never found to form more than 4% of the ground cover and the slope at the sites never exceeded 15°. All sites were found to have been at one time subjected to logging (indicated by the presence of stumps) and six of the eight sites had been burnt sufficiently recently that blackening of trunks and logs was obvious.

Between 1994 and 1997 a total of 64 pre-logging and 68 general surveys were performed in the two Districts. Both pre-logging and general surveys consisted of aural and visual components with the survey starting with a five minute listening period followed by a call playback (1.5-3 minutes) and then another five minute listening period. Visual surveys of the riparian area were then performed using spotlights. The minimum total estimated time spent on each of these methods was 1460 minutes of call listening around 483 minutes of call playbacks and 6.1km of riparian zone visually surveyed. In addition, roads were also searched for frogs when either travelling to each survey site or as a specific targeted search for the frog (used particularly on very wet nights) with a minimum of 352 km of road being surveyed in this manner. Notably, this latter method has recently been recommended as a suitable means of locating this species (NPWS/SFNSW, 1997).

DISCUSSION

These recent records demonstrate that the giant burrowing frog is still present in far southern N.S.W. and that they are scattered over a relatively wide area (Figure 1). However, the records are patchy and few so that the status of the species cannot be assessed as better than rare at this point in time. Furthermore, as the records are so widely scattered is also not clear whether there is one contiguous population or that there are several isolated populations present.

General texts consider the giant burrowing frog to be a species found within more open forests and heathland (Gillespie, 1990, Cogger, 1992; Tyler, 1992; Daly, 1996). However, records made by Gillespie (1990) and Littlejohn and Martin (1967) from the Victorian side of the border indicate that this species will inhabit taller, wetter forests. This species has not been found within heath in Victoria despite extensive surveys in this habitat type (Gillespie, pers. comm.). The records obtained in this study were all made in areas considered to be dry sclerophyll to low open dry forest and often with a grassy/shrubby component to the understorey, which is in keeping with the views of the first authors. Suitable areas of moister forest are present in the region and were surveyed, particularly in the Narooma District, but no frogs were located there. Perhaps then, dryer forests and heathlands are the preferred habitat in the southern part of this species' range. If so, this frog is changing its habits in eastern Victoria and so populations there are of added interest.

Although the limited number of records and lack of comparative "negative" sites does not allow any firm conclusions to be drawn from the habitat data, a few micro-habitat preferences appear obvious from the features measured.

None of the records came from a slope greater than 15 degrees, which may suggest a preference for areas of slighter relief. However, as most records were associated with a road and roads are built on flatter areas of land, this may not be a true reflection of the species preferred habitat. There may have been some significance in relation to the type of ground cover present with all but one site having 25% or less shrub component (mostly 10% or less). Perhaps as they are large frogs they may find travelling through thick vegetation more difficult and so avoid such areas. However, they are found in dense heathland in other areas such as Barren Grounds Nature Reserve (J. Recsei, pers. comm.) and so this appears not to be the case. The data collected here then may simply confirm that this frog is a relative generalist in terms of the microhabitats in which it will live. This conclusion is supported by Webb (1991b) who was unable to find habitat variables which strongly predicted the distribution of this frog. Habitat preferences will only be determined by obtaining more record sites to compare with sites at which this species is confirmed to be absent. As discussed later, however, it is difficult to know when this species is truly absent from a site.

Six of the eight records were of frogs found on roads at least 50 metres away from any form of water body or drainage line. This is the same situation found by Webb (1983) and demonstrates that this frog is a highly mobile species which moves away from riparian habitats, at least during wet conditions. It is possible that giant burrowing frogs spend considerable periods of time away from the riparian zone, returning only to reproduce or to retreat to this moister habitat during dryer times. If so, protection of the species from disturbance may require more than just the reservation of riparian vegetation. Further work is required to determine the overall habitat usage patterns of this species.

The ability of this species to cope with disturbance remains unclear. The only study which has attempted to quantify the impacts of logging on the giant burrowing frog was that of Webb (1991b). He studied the effects of logging on the abundance of this species in the Eden area in the late 1970s and early 1980s and found that there was a notable decline after logging, but that the changes were not statistically different (which he acknowledged may have been due to small sample sizes). The habitat data collected in this study indicates that giant burrowing frogs are currently present in areas which have a history of both logging and burning. However, the site information indicated a possible preference for older forests and a possible negative influence of disturbance. These two results suggest that this frog is intolerant of the initial disturbance to an area (which reduces the vegetation), but is able to utilise the habitat again after sufficient regeneration has occurred. How long it takes for populations to reach pre-logging levels and how depressed they may be by particular levels of disturbance is unknown.

Notably, none of these recent records have been obtained from within conservation reserves. This is presumably a reflection of the dearth of survey effort within these areas in recent years, with the previously mentioned increased effort being directly almost entirely at timber production lands. However, other species are considered to have declined within reserved lands equally as much as in non-reserved habitats (Richards et al, 1993; Mahony, 1996) and so confirmation is required that this frog is present in areas such as Nadgee Nature Reserve where old records are available for this species (J. Recsei, pers. comm.). For species where we do not yet know the cause of their rarity it may be reasonable to take a more diversified approach to their conservation and ensure that there are populations in both newly reserved habitats and also populations left in habitats which remain being utilised in their recent historical manner.

It was considered that this species would most likely be located through the commonly used methods of call listening and call playback. However, only two of the records listed in this

paper were obtained using this method, the other frogs being recorded incidentally by workers when undertaking other activities. This is despite the fact that survey effort has increased greatly in recent years through the provision of pre-logging surveys in all forestry compartments nearby to known record sites for this frog and the undertaking of widespread regional surveys as part of the Comprehensive Regional Assessment Process (CRA). Both sets of surveys have used call listening followed by call playback and whilst field workers employed in both sets of surveys were not necessarily recognised experts in the survey of frogs, they have been able to locate other species of rare frogs in the area using the same techniques (see Lemckert et. al., 1997). It would appear more reasonable to suggest that this species is in fact difficult to find using call listening and call playback. If these methods of survey rarely succeed, then current survey results are likely failing to detect populations which would otherwise be considered for protection. Therefore, it would appear important that techniques for surveying this species be re-considered when undertaking future surveys. Perhaps surveys for tadpoles can be considered as an alternative as these will be present for the majority of the year, can be surveyed for in the daytime and are reasonably easy to locate (J. Recsei, pers. comm.; F. Lemckert, pers. obs.)

The records presented in this study confirm that the giant burrowing frog is still present through the south-east corner of NSW. However, the limited number of records and their patchy nature indicates that the future of the species in the area should be considered uncertain. More information is required on the reproductive habits and success of the frog in the area as this stage may be the most critical in terms of potential declines in this species. The data presented in this report indicates that the giant burrowing frog currently persists in logged forests, but it is not yet known if there is a decline in logged forests. Further research on the movements and survivorship of frogs post-logging is required. Finally, the value of reservations in protecting this species from future declines needs to be established.

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Figure 1. Survey sites for Heleioporus australiacus

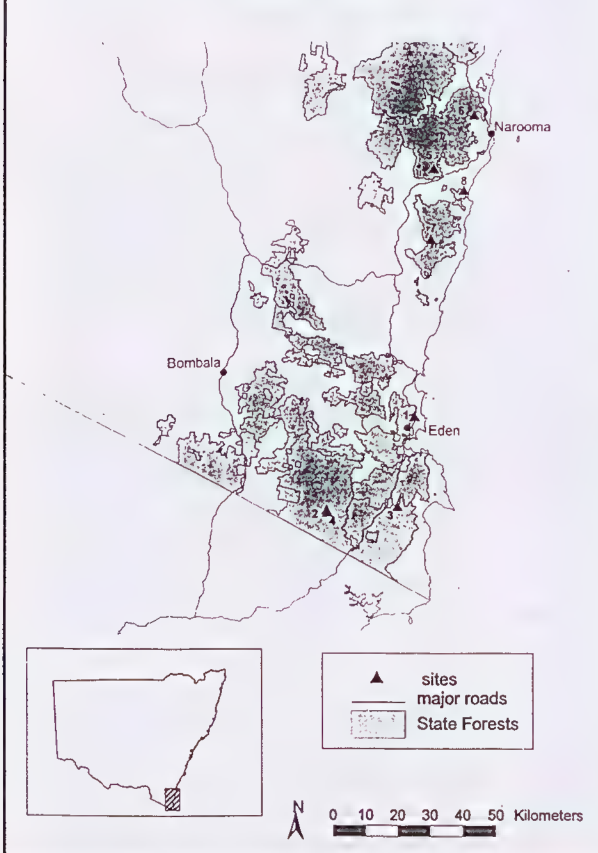

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Table 1. Measured habitat features

Site	Altitude	Geology	Aspect	Position on slope	Slope in Degrees	Succession Stage	Disturbances	Litter Depth	Soil Type
1	150	Dms	0	R	0	ARe	Logging, Fire	4 cm	3
2	400	Dlwa	100	M	12	ERe	Logging, Fire, Clearing	1 cm	3
3	440	Ou	210	R	3	ARe	Logging, Fire, Clearing	1 cm	3
4	420	Dlwa	350	M	8	ARe	Logging, Fire	1 cm	3
5	120	Ou	120	UM	15	ARe	Logging, Fire	2 cm	
6	150		150	R	10	M	Logging	2 cm	
7	140		165	R	9	ERe	Logging, Fire	2 cm	5
8	10		0	G	0	ARe	Logging	5 cm	

Legend:

Position on slope

G=Gully
F=Flat
R=Ridgetop
M=Midslope
L=Lower Midslope
UM=Upper Midslope
A=Alluvial

Succession Stage

ERe - Early Regeneration
ARe=Advanced Regeneration
M=Mature

Soil Type

1=Loam
2=sand
3=sandy loam

Geology

Sedimentary = Dms, Ou
Igneous (intrusive) = Dlwa, Dlrg
Alluvial = Qa

Table 1 continued

Site	% Canopy	% Understorey	Canopy height	Ground Cover % Litter	Veg	Grass	Logs	Ground cover vegetation
1	51-70	31-50	25	94	10	48	3	bracken fern, other fern spp., grasses
2	31-50	<30	20	5	15	70	0	bracken fern, wiry ricegrass
3	31-50	<30	25	30	0	30	4	wiry ricegrass, bracken fern, Gahnia sp.
4	31-50	<30	26	30	45	10	2	wiry ricegrass, other grasses
5	>71	<30	25	50	0	40	0	kangaroo grass
6	>71	31-50	30+	80	0	20	0	grasses
7	31-50	31-50	20	65	5	10	10	prickly shaggy pea, grasses, shiny cassinia
8	51-70	<30	30+	0	0	95	5	grasses

OBSERVATIONS OF NOCTURNAL BASKING AND ACTIVITY IN SEVERAL AGAMID SPECIES

Robert A. Valentic 11 Mulgowrie Court, Greensborough, Victoria 3088.
Grant Turner 103 Settlement Road, Bundoora, Victoria 3083.

INTRODUCTION

Nocturnal activity and nocturnal basking have been reported in some species of Australian agamids which are otherwise known to be diurnal in habit. In particular these behaviours have been recorded in the following species (denote A=active, B=basking), ?= not specified): *Diporiphora sp.* (A) and *Tympanocryptis lineata* (A) (Fyfe 1981), *Amphibolurus nobbi* (A), *Ctenophorus fordi* (A?) (Morley & Morley 1982), *Pogona minor* (A) and unidentified spp. (B) (Bush 1983), *Diporiphora bilineata* (A), *Diporiphora magna* (A) and *Lophognathus gilberti* (A) (Bedford 1991), *Pogona minor minor* (B) (Orange 1992) *Moloch horridus* (A) (Niejalke 1994), *Diporiphora bilineata* (A), *Lophognathus gilberti* (A) and *Pogona vitticeps* (A) (Valentic 1995), *Ctenophorus caudicinctus* (?) (Sonneman 1996). Thus to date nocturnal behaviour has been recorded in seven genera of Australian agamids suggesting it is more widespread than previously thought in this family. However the function of this behaviour is not always apparent and so there is a need to carefully document the circumstances under which observations take place, and where possible, the details of specimens involved.

We report on nocturnal behaviour in two gravid female *Ctenophorus nuchalis* lying on bitumen road surfaces at night and a single gravid female *Tympanocryptis tetraporophora* apparently active on a bitumen road at night. Some additional brief notes on nocturnal activity in *Chlamydosaurus kingii*, *Tympanocryptis cephalus*, *C.nuchalis*, *C.cristatus* and *Diporiphora lalliae* are also described.

OBSERVATIONS

The following abbreviations are used below: EST- eastern standard time, CST- central standard time, SVL- snout-to-vent length, TL- tail length, from vent to tip, HL- head length, from tip of rostral scale to anterior edge of tympanum, HW- head width at mid-tympanum level. SVL and TL measurements were taken using a rigid 500mm ruler (1mm gradations) and head measurements using a vernier calliper accurate to 0.02mm.

C.nuchalis

At 2044hrs (CST) on 19 October 1996 a suspected road-kill *C.nuchalis* was observed on the Tablelands Hwy (136°00'E, 19°23'S), 44km north-east of the Barkly Homestead, central-east NT. Weather was warm with clear skies, half-moon and a gentle breeze. Air temperature was 31.6°C, bitumen surface temperature 32.3°C and relative humidity 28%; the area had not received rain during last few days. Habitat consisted of *Acacia* shrubland plain on red stony soils with numerous small termitaria. The sun had set at 1844hrs (CST) that evening and it was dark when the observations occurred. Day-time weather was still, clear and sunny with a maximum temperature of 34°C.

On closer inspection the specimen was observed lying prostrate against the bitumen with both eyes closed and was apparently uninjured. When touched the eyes opened, but otherwise the lizard remained motionless. On being picked-up it was very warm and began to struggle vigorously. It was a small female and was conspicuously gravid. Its dimensions were: SVL=55mm, TL=72mm, HL=13.3mm, HW=13.5mm. The specimen was retained for 24hrs and closely inspected

in order to ascertain that it had not been injured by a vehicle. The lizard had not been visible on the road surface at approximately 1820hrs earlier in the evening, indicating that it had moved onto the road surface in between these times.

At 2033hrs (CST) on 22 October 1996 a suspected road-kill *C.nuchalis* was observed on the access road to Poseiden Gold Pty Ltd mine (134°18'E, 19°14'S), 15.2km south-east of the Tennant Creek township (19°38'S, 134°12'E), central NT. This specimen was present on the road surface when traversed at approximately 1945hrs (CST) earlier in the evening. Weather was warm with clear skies, half-moon and a gentle breeze. Air temperature was 33.0°C, bitumen surface temperature 33.5°C and relative humidity 28%; the area had not received rain during the past few days, although pools occurred on some roadside verges and both *Cyclorana australis* and *Litoria rubella* were active nearby. Habitat consisted of shrubland on red stony soil plain with numerous small termitaria. The sun had set at 1847hrs (CST) and it was dark when observations occurred. Day-time weather was still, clear and sunny with a maximum temperature of 35°C.

The specimen was observed lying prostrate against the bitumen with both eyes closed, apparently asleep. When the dorsal surface was touched the eyes opened but otherwise the lizard remained motionless despite us having driven over the top of it twice. On being picked-up it was very warm and began to struggle vigorously. It was a heavily gravid female. Its dimensions were: SVL=91mm, TL=114mm, HL=18.9mm, HW=18.8mm. It was closely inspected to ascertain that it had not been injured by a vehicle, although none were seen on this particular road during the evening.

T.tetraporophora

At 1905hrs (EST) on 10 October 1996 an agamid was observed on the Landsborough Hwy (142°50'E, 22°08'S), 35km north-west of Winton (143°03'E, 22°23'S) in central-west QLD. The lizard had an alert semi-upright stance with tail arched, the anterior body and head lifted clear of the road surface; the groin and limbs were in contact with the surface. Weather was warm, with 40% cloud cover, no moon and a gusting east wind. Air temperature was 29.0°C, bitumen surface temperature 29.6°C and relative humidity 39%. Habitat consisted of Mitchell grass (*Astrebla* sp.) plain with dark brown, friable cavity-forming soils. The sun had set at 1805hrs (EST) that evening and it was completely dark at the time the observation occurred. Day-time weather was sunny with a warm breeze and a maximum temperature of 37°C.

On closer inspection it was found to be a heavily gravid adult female *T.tetraporophora*. It attempted to flee on our approach, moving quickly to avoid being captured. On being secured (after about 20sec) it was noticeably warm. Its dimensions were: SVL=65mm, TL=91mm, HL=20.8mm, HW=14.64mm. There was little traffic on the road with no vehicles having traversed the highway at least 20min before the observation occurred.

ADDITIONAL OBSERVATIONS

In addition to these observations, G.Fyfe (pers.comm.) has observed basking and nocturnal activity in *C.nuchalis* and *Diporiphora lalliae*, M.Kearney (pers.comm.) has observed nocturnal activity in *Ctenophorus cristatus* while R.Pails (pers.comm.) has observed nocturnal activity in *Chlamydosaurus kingii* and *Tympanocryptis cephalus*. The observations are described separately below:

Ctenophorus nuchalis: Three adult *C.nuchalis* were observed lying prostrate on Larapinta Drive (Western MacDonnells road) between Alice Springs and Hugh River in central-south NT on different evenings and times of the year. Approximate times for each sighting were 20:30, 22:00 and 23:00hrs (CST). None of the lizards appeared to be injured. Hemipenes were manually everted in two of the specimens.

Diporiphora lalliae: More than three adult *D.lalliae* were observed in alert upright postures on a section of the Tablelands Hwy traversing the black-red soil intergrade habitat near Alroy Downs, central-east NT. Observations occurred on a warm evening after 21:00hrs (CST). Roadside pools indicated recent rain and significant insect activity was noted.

Ctenophorus cristatus: At 21:15hrs (CST) on 27 January 1996 an active adult male *C.cristatus* was observed crouched on a dirt track cutting through mallee habitat on the Kimba road of the Middleback Ranges, SA. Conditions were as follows: air temperature 20°C, relative humidity 66%, no rain, wind or cloud cover and half-moon.

Chlamydosaurus kingii: At approximately 21:30hrs on 12 January 1994 an adult female *C.kingii* was observed in an alert upright stance 1km east of the Stuart Hwy on the Edith Falls road (90km north of Katherine), NT. This bitumen road cuts through dry woodland. Weather was stormy with recent rainfall (early that evening) and day-time conditions were 'hot' (>30°C).

Tympanocryptis cephalus: Between 20:45-21:30pm on 13 January 1994, five or six adult *T.cephalus* were observed in alert upright stances on the Orlando Mine road west of the Tennant Creek township. There was an approaching storm and the day-time conditions were warm and dry.

DISCUSSION

Climatic factors common to nearly all published reports of agamid nocturnal behaviour are high temperatures and the presence of moonlight. Usually the night-time conditions are described as 'warm' (>20°C) and/or preceding day-time conditions as 'hot' (>30°C). Other possible influences such as rain or high relative humidity do not appear to be necessary precursors. The occurrence of gravid females on bitumen roads with temperatures above ambient air suggests that lizards were attempting to conduct heat from the road surface. This seems particularly likely in the case of *C.nuchalis* given their flattened postures. Similar postures appear to have been recorded by Bush (1983) who noted some agamids spotlighted at night as lying 'belly down' on granite or bitumen. Bedford & O'Grady (1996) described a peculiar 'belly up' posture in gravid female *Tympanocryptis lineata* lying on bitumen roads. We were not able to measure the body temperature of the lizards to ascertain whether their body temperatures were above ambient. It may also be significant that the majority of the observations of nocturnal basking/activity occurred in northern or central Australia (all except Bush 1983, Morley & Morley 1982, Niejalke 1994, Kearney - above) and that none occurred during the cooler/drier months of the year (from May through September). This would tend to emphasize the importance of temperature.

Nocturnal activity in some agamids has been observed to include foraging on insect debris on roads (Fyfe 1981, Bedford 1991, Valentic 1995, also see Bush 1983) and this cannot be ruled out in the case of the gravid *T.tetraporophora* for example. Niejalke (1994) suggests nocturnal sightings of agamids may result from either natural or human induced disturbance. We could not identify any extraordinary natural stimuli to account for our observations however it is always possible that approaching car headlights create the false impression of day-time, thus stimulating activity and possibly luring lizards onto road surfaces. This explanation does not account for the observations of *C.nuchalis* however and presumes that dragons can respond quickly to such stimuli.

While the bitumen temperatures we recorded were in each case above ambient air temperatures, the difference between the two was quite small (<1°C). Bedford & O'Grady (1996) in describing a peculiar belly-up posture in *Tympanocryptis lineata* doubted a thermoregulatory explanation of this behaviour, noting that ground and air temperature 'appeared similar' however differences of the magnitude that we recorded would not be

detectable unless measured. One cannot also discount the possibility that at the time the lizards moved onto the road surface the difference between the two was greater.

The question arises as to how long into the evening nocturnal basking and activity continues. In the case of *C.nuchalis* which is known to use burrows as nocturnal retreats, (as *Amphibolurus inermis* in Heatwole (1970) and Rankin (1977)) it would be of interest to know how their burrow temperature compares to road temperature and whether sleeping in the open increases their vulnerability to predation (see Sonnemann's (1996) observations of *C.caudicinctus*). There is also the more general question as to whether gravid female dragons spend more time basking than other conspecifics as is known to be the case in other, primarily viviparous, squamates (see Shine 1980).

ACKNOWLEDGEMENTS

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A RANGE EXTENSION FOR THE DELICATE SKINK, *LAMPROPHOLIS DELICATA*, IN TASMANIA

Michael M. Driessen and Raymond Brereton
Parks and Wildlife Service, Tasmania
GPO Box 44A Hobart 7001 Tasmania Australia

Lampropholis delicata is found in eastern Australia from north east Queensland to south east South Australia, including Tasmania (Cogger 1992). Within Tasmania the species has been found in a variety of habitats in the warm lowlands of northern and eastern Tasmania (Figure 1). A specimen of *Lampropholis delicata* was found on the north west coast of Tasmania on 7 April 1996. This locality is well outside the previously published range for this species in Tasmania (Rawlinson 1974). The closest known record for the species is over 150km to the east. The specimen was found 14km south-west of the town of Marrawah at 41° 02′ 06″ S and 143° 37′ 53″ E, it was 200 metres from the coast and at an altitude of less than 10m above sea level. The skink was found under a piece of roofing iron at the interface of short grassland and *Melaleuca squamea* forest. The grassland contained a mixture of native and exotic species and is used for grazing stock. It was found at approximately 2pm on a cloudy day when the temperature was 16°C. The specimen was 46mm snout vent length and 118mm total length. The specimen has been lodged with the Queen Victoria Museum, Launceston, Registration Number 1988:3:2.

L. delicata is one of three species of egg-laying reptiles occurring in Tasmania, the others being the eastern three-lined skink, *Bassiana duperreyi* and the mountain dragon, *Tympanocryptis diemensis*. Most of Tasmania's reptiles bear live young which pre-adapts them to cold climates as it eliminates the need for warm, humid nest sites and allows active incubation of the embryos (Rawlinson 1974). Thus the distribution of egg-laying reptiles in Tasmania is largely restricted to the warm climatic zone of Tasmania as described by Gentilli (1972). The warm climatic zone occurs as a narrow coastal band which extends from the east coast of Tasmania, across the north coast and extends down the west coast to Macquarie Harbour. All previously known locations of *L. delicata* occur in the warm climatic zone in the north east and east of the State. The new location for *L. delicata* also occurs in the warm climatic zone but on the remote north-west coast - where few reptile surveys have been conducted. Thus, we consider that this record is a range extention rather than an introduced animal. Further searches in the warm climatic zone in north-west and west Tasmania should yield additional collections of *L. delicata* and perhaps the other egg-laying reptiles.

ACKNOWLEDGMENTS

Thanks go to Joe King for his hospitality on the day of collection and Maria Moore for producing the distribution map.

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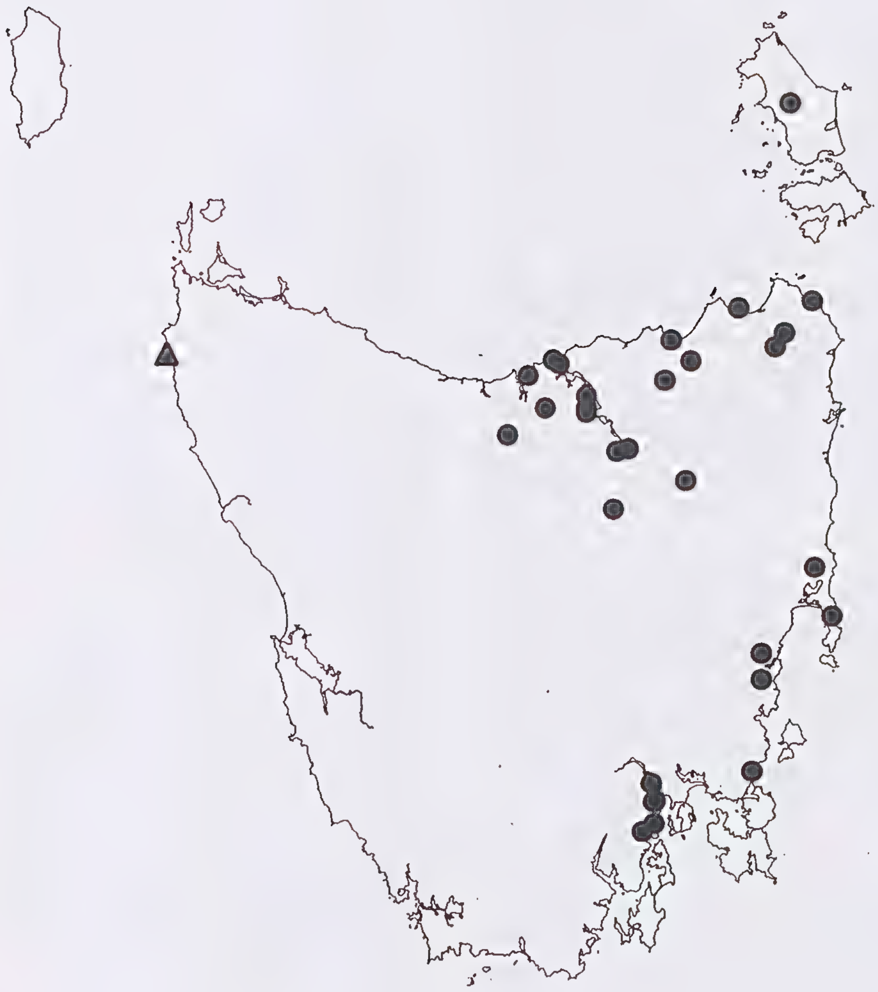
Figure 1 Known distribution of *Lampropholis delicata* in Tasmania. Circles denote records from Rawlinson (1974) and the Tasmanian Wildlife Atlas, Tasmanian Parks and Wildlife Service. Triangle denotes new distribution record.



EVIDENCE OF DIURNAL MATE-SEARCHING IN MALE LITTLE WHIP SNAKES, *SUTA FLAGELLUM* (ELAPIDAE).

Grant Turner
103 Settlement Road, Bundoora, Victoria 3083.

INTRODUCTION

Little is known of the daily and seasonal movements of Australian elapid snakes (Shea *et al* 1993). Radio-telemetry studies of several large diurnal elapids (*Pseudechis porphyriacus, Notechis scutatus* and *Austrelaps superbus*, Shine 1979, *P.porphyriacus*, Shine 1987) indicate that males generally have more extensive movements and larger home ranges than females. Mate-searching behaviour has not been studied in detail in any Australian elapid but from the limited information available it appears that in several species males actively seek out females, rather than the converse, and when engaged in mate-searching behaviour move greater distances than females (Shine 1987, 1991, Fearn 1993, Shea *et al.* 1993 but see Rankin 1976). Similar behavioural patterns have been documented in a variety of exotic snake species (see Gregory *et al.* 1987, Mason 1992).

In this note I describe several observations of the small nocturnal elapid the Little Whip snake (*Suta flagellum*) (Cogger 1992), indicating they have a mate-searching strategy similar to that described above. In particular I describe two observations of males becoming active and apparently seeking out and consorting with females during daylight hours. An explanation is suggested for this behaviour.

OBSERVATIONS

Observations took place approximately 17km west of Melbourne at Deer Park (144°46'E, 37°46'S). The area is gently undulating with abundant surface basalt and supports several large 'islands' of remnant grassland some 4km² in extent dominated by Kangaroo grass (*Themeda triandra*). *S.flagellum* is a common inhabitant of these grasslands and is easily located beneath surface rock and large outcrops throughout the volcanic plains to the north and west of Melbourne during cooler months (May to October; Fyfe & Booth 1984, Turner 1989). The area was visited regularly for the purpose of conducting a population census of *S.flagellum*. It was first surveyed in May 1991 and was visited each month until December of that year. Surveys involved the location of *S.flagellum beneath* rocks and the recording of length measurements (SVL=snout-to-vent length, TL=tail length, etc.), sex, description of colour and markings. and are described fully in Turner (in prep.). Each snake was noted for the presence of identifying marks and there was no removal of individuals until completion of the census. It has been observed that the species first appears beneath surface rock in late autumn and early winter and individuals tend to remain there usually beneath the same rock until spring or early summer (Turner 1989). They do not appear to engage in nocturnal activity during this period.

By early October 1991 a total of 35 individuals had been recorded in the census consisting of 12 adult males, 7 adult females, 9 juvenile males and 7 juvenile females. *S.flagellum* is often found overwintering in small aggregations (James 1979, Fyfe & Booth 1984) and in the census eight aggregations had been located. Denoting adults by upper case letters, juveniles by lower case letters and making the obvious abbreviation for each sex, the composition of the aggregations was as follows: 3xMF ('pairs'), Mmf, Fm, Mf, Ff, mf. The census of the area was incomplete at the time the observations described below occurred.

On 5 october 1991 the area was visited from 1000-1530hrs (EST). During the previous week weather conditions were characterised by cool, clear sunny days with maximum day time temperatures around 19°C and correspondingly

cold nights with minimum temperatures around 11°C. This is fairly typical spring weather for the region (nearest weather recording station is at Laverton, 9km south of Deer Park: October mean daily max.19.0°C, min.8.1°C). On the particular day concerned the temperature was unusually high reaching a maximum of 33°C by mid-afternoon. All rocks known to be occupied by snakes previously recorded in the census were checked. Substrate temperatures beneath rocks (recorded by inserting a temperature probe through gaps between the rock and substrate, prior to lifting the rock) where snakes resided were however still quiet cool (range 12-15°C, n=12). Individuals found beneath rocks were sluggish and incapable of rapid movement; most did not move significantly or at all when rocks were removed during inspection.

It was evident however from inspections that certain snakes had moved from beneath surface rocks. Moreover this movement was almost entirely confined to the 'single' adult males (i.e., those which had not paired up with an adult female) of which there were nine. This male bias in movements was statistically significant when compared to the expected equal frequency of both sexes ($P<0.01$; x^2 with Yates correction; a 1:1 sex ratio was determined in Turner, in prep.). Single females and adult male-female pairs had not moved. Movements were found to have occurred in only three juveniles (two males and one female). While it is possible that the snakes had moved in response to being disturbed sometime during the census, this does not explain the observed male-bias in movements.

A thorough search of surface rocks in the area failed to locate any of the previously recorded single males or any new males, although a previously unrecorded adult female and two juvenile females were separately located.

While photographing the adult female *in situ* on the bare earth substrate where the rock had been removed, an adult male emerged from the base of surrounding *T.triandra* tussocks. This occurred some 10 mins. after initially uncovering the female at about 1240hrs (EST). The male emerged from tussocks on the opposite side to my approach without any apparent hesitation and seemed completely oblivious to my presence, though I remained still during this time. It showed immediate interest in the female and displayed the initial stages of courtship behaviour (see Turner 1992). Having first located the female's vent it flickered its tongue along the length of her body. The female remained still. This behaviour continued for about 2mins. until I made a slight movement resulting in the male retreating very swiftly into surrounding grass tussocks. The specimen was located within seconds and upon handling it was noticed that the snake was quite warm. While its body temperature could not be measured, it was clearly well above those individuals found beneath rocks, indicating that it had been out in the open for some time. It was extremely active and aggressive when handled. The ground temperature in the open was 35°C. This male had not previously been recorded. The measurements of both specimens were: female- SVL=283mm, TL=37mm, male- SVL=333mm, TL=57mm.

Attention was then focused on the search for other male *S.flagellum* in and around grass tussocks rather than beneath rocks. This search was unsuccessful with no other snakes being located. The dense *T.triandra* ground layer and relatively small adult size of the species would have made evasion very easy, particularly if snakes were active.

A further observation was made four weeks later on 2 November 1991 at 1300hrs (EST) at the same locality but in grassland some 500m away. Weather was overcast and warm with a maximum temperature of 31°C while the previous night's minimum was 9°C. An adult male and female *S.flagellum* were observed in a 'mat' of *T.triandra* leaves at the base of a rock which was partly concealed by *T.triandra* tussocks. The rock consisted of a removable corner block of basalt where the female had been recorded on a previous occasion (26 October). The ground temperature at the base of the rock, within 0.1m of the pair, was 27°C. The temper-

ature down the crevice formed by the block was 22°C. The male was active and moving in a confined area around the inactive female though the nature of this activity could not be determined due to them being partly concealed. On handling they were warm and highly active. This male had not been previously recorded and was not present at this rock when inspected on four previous visits during the year. The measurements of both specimens were: female- SVL=269mm, TL=42mm, male- SVL=361mm, TL=62mm.

DISCUSSION

The observations described above suggest that male *S.flagellum* actively seek out females during spring and that this activity may occur during daylight hours.

S.flagellum is known to be nocturnal in habit with individuals in both the field and captivity found beneath rocks and ground debris during daylight hours (Rawlinson 1965, Jenkins & Bartell 1980, Fyfe & Booth 1984). The observations of diurnality in males are thus of interest. Exceptions to the nocturnal habit recorded to date involve gravid females that often emerge to bask, but are not active as such during daylight hours (see Turner 1985, 1996), and also a single observation of a male copulating in the open with a concealed female in mid-October (Valentic 1993). Besides these, I have only observed two other instances of individuals being located away from cover during daylight hours, although it is uncertain to what extent this paucity is a genuine reflection activity patterns or the result of observer bias. At 1120hrs on 10 July 1993 an adult male (SVL=302mm, TL=40mm the last 15-20mm of which was missing) was observed perched motionless on the burnt stub of a grass tussock apparently basking on a cool overcast day (intermittent sun, daytime max. 14°C). It had severe lesions along much of the dorsal surface and tail, which had probably resulted from a fire that had swept through the area in April. The specimen was some 2m away from the nearest ground cover (surface rock) and the intervening ground was largely exposed earth with charred remains of grass tussocks. The second instance occurred at 1232hrs on 30 August 1996 when a subadult female (SVL=183mm, TL=27mm) was observed apparently basking on a cool but sunny day (daytime max. 17°C) at the base of a embedded rock face (0.5x0.4m). It lay motionless and was perched approx.15mm above the substrate, being loosely draped over folded grass leaves with the head concealed. It was warm and quite active when handled. The specimen was about 1m away from the nearest rock cover and the intervening ground had dense grass cover. As in both instances the snakes were inactive (although they presumably moved to and from the basking site to their refuge), it would appear that the observations of active males described above represent the only record of diurnal activity in the species.

Why do males become day-active during spring and not at other times of the year? The observations would suggest that the location of females is signifiant in males becoming active. *S.flagellum* is known to mate in spring (October-November; Turner 1989, 1992, Valentic 1993) and there are only two records of captive matings outside this period (May and June; Fyfe 1980, Fyfe & Booth 1984). Why males become active during day-light hours may be explained by the occurrence of unsuitably low night-time temperatures during the spring period. The mean daily minimum temperatures during the spring months at Laverton are: Sept. 6.5°C, Oct. 8.1°C and Nov. 9.9°C. In captivity *S.flagellum* rarely emerge from refugia when temperatures fall below about 10°C (pers.obs.; the voluntary thermal minimum has not been determined for this species). If single male *S.flagellum* do engage in mate-searching whenever temperatures permit, then daytime movements would seem likely during these months as temperatures during daylight hours are usually considerably higher than at night. On this basis the only other period of the year when daytime activity in males might occur is in late autumn when it seems that males may attempt to locate females (as indicated by the occurrence of MF overwintering aggrega-

tions) and night temperatures are quite low (mean daily minimums: April 9.9°C, May 7.7°C). To date such movements have not been observed. A related question is whether daytime activity in males is associated with an increased risk of predation. Diurnality would potentially expose males to a different suite of predators than night activity though whether this risk is a significant one is presently unknown.

It is interesting to consider the problem of how male *S.flagellum* locate females. In captivity I have always maintained *S.flagellum* in small groups with an excess of females. Given this and the space limitations of the captive environment, locating females would not be difficult nor incur a significant energetic cost to males. Hence one would not expect, and does not see, diurnal activity in captive males. However under field conditions one would expect mate-searching to generally take considerably more time and effort. Olfaction is strongly developed in snakes and it is known that the problem of locating conspecifics (trailing) involves the ability to follow species/sex specific scent (pheromone) trails (Ford 1986, Ford & Holland 1990, Mason 1992). Just how difficult this task is for *S.flagellum* in the field cannot be gauged although the common occurrence of overwintering aggregations in the species, despite the abundance of apparently suitable surface rock, suggests it may be relatively simple. At those times of the year when *S.flagellum* is night-active, scent trails are presumably fresh and thus easier to follow. However in early spring, following 3-4 months of inactivity, scent trails could conceivably go 'stale' so that locating a female may involve considerably more effort in early spring than in late spring or autumn. This might also have some influence on occurrence of daytime activity in males during spring.

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CIRCUMDUCTION AND HEAD BOBBING IN THE AGAMID LIZARD *LOPHOGNATHUS TEMPORALIS*

Sean J. Blamires
c/o Department of Biology, Northern Territory University
Darwin NT 0909

Circular waving of the forelimb, or circumduction, is a behaviour common among agamid lizards (Bustard 1968, Ferguson 1977, Witten 1993). Theories of its function vary. A dominant - subordinate display, depending on the speed of limb movement has been proposed for a number of *Amphibolurus* species with dominants engaging in 'fast' circumduction to signal territory ownership and subordinate and irnmatures engaging in 'slow' circumduction to avert aggressive behaviour by dominants (Carpenter el al. 1970, Brattstrom 1971, Ferguson 1977). In *Ctenophorus fordi* it has been described as a warning display, since it mainly occurs when an individual is perched high and alert (Cogger 1978). In *Amphiholurus maculosus* it has been proposed to represent a sexual display employed only by females to deter undesirable males (Mitchell 1973). In *Lophognathus gilberti* it has been described as resembling bidding farewell, since it is usually preceded with a sprint (Witten 1993).

Head bobbing behaviour is a common trait among agamid lizards (Ferguson 1977, Gibbons 1979) and is usually performed by adult males as a signal of territory ownership, courting behaviour, conflict or threat (Ferguson 1977, Gibbons 1979, Witten 1993). Many snakes and lizards are known to employ 'distraction displays', such as tail wriggling, or caudal luring (Greene 1973, Alcock 1984). Caudal luring has been found to be associated with tail autotomy and/or brightly coloured tails (Greene 1973).

While studying the tropical agamid, *Lophognathus temporalis* from 1996, through 1998, at several localities within suburban Darwin, Northern Territory, I observed several instances of circumduction and head bobbing, which are presented in table 1. Circumduction was mostly performed by Juveniles (87.5%) and mainly when the lizard was on the ground (90.0%) and was observed to always be followed by fleeing to cover upon movement of the observer. Only fast circumduction was observed. The behaviour was more predominant in sub-adults and juveniles, however it was employed by adults on occasions. It was employed independent of the presence of conspecifics. Therefore a communicative role could not be applied to this behaviour. Head bobbing was exclusively employed by large adult males during the breeding season (September throughout to the following February) and was also always followed by fleeing to shelter upon movement of the observer. These head bobs were directed toward the observer in the absence of any conspecifics, these were interpreted as a threat display.

It is proposed here that circumduction in *Lophognathus temporalis* may be a distraction display to potential predators. This is in accordance with the behaviour observed, since the initial flight into the open would focus a predator's attention to that area, while the lizard quickly ran to cover. Another possible role of circumduction may be a 'recognition' signal to the predator as has been proposed for stotting behaviour in Gazelles (Alcock 1984). This would imply that the circumducting lizard is signalling to the predator awareness of its presence, discouraging further pursual. The role of head bobbing as a threat display by large adult males during the breeding season agrees with observations on other agamids (e.g. Mitchell 1973, Gibbons 1979) that head bobbing, is a display of dominance, territory ownership

TABLE 1

Observations of circumduction and head bobbing in *Lophognathus temporalis* in study period.

CIRCUMDUCTION

	ADULT MALES		OTHER ADULTS		JUVENILES	
	ground	trees	ground	trees	ground	trees
	0	0	5	0	31	4
conspecific present	0	0	0	0	9	2

HEAD BOBBING

	ADULT MALES		OTHER ADULTS		JUVENILES	
	ground	trees	ground	trees	ground	trees
	12	6	0	0	0	0
conspecific present	0	0	0	0	0	0

and threat, possibly to subordinate males and other intruders of the lizards territory. The fleeing behaviour in response to the observers movements would indicate that these threats are merely bluff tactics. The role of these behaviours however, may vary among the agamid genera.

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HERPETOLOGICAL NOTES

A LOW ELEVATION RECORD FOR THE RAINFOREST GECKO *CARPHODACTYLUS LAEVIS* AND A FURTHER ADDITION TO THE HERPETOFAUNA OF THE MOSSMAN GORGE SECTION OF DAINTREE NATIONAL PARK, QLD.

Geordie A. Torr
Dept of Zoology and Tropical Ecology, James Cook University, Townsville, 4811

Previous authors have suggested that the carrot-tailed or chameleon gecko, *Carphodactylus laevis*, is confined to upland rainforest (Wilson and Knowles, 1988; Covacevich and McDonald, 1991). On the 20th of October, 1996 at approximately 10pm I encountered an adult male carrot-tailed gecko (SVL=100mm) crossing a path in Mossman Gorge National Park (16° 29′ S, 145° 20′ E; 150m asl). This record corresponds with other sightings of this species in the Cape Tribulation area, also at low elevation (L. Mason, pers. comm.). These records have important implications for predictions about the species' distribution, ecology and biogeographic history. They also highlight our lack of knowledge of the general ecology of this species and of the herpetofaunal communities inhabiting Australia's tropical rainforests.

Another addition to the herpetofauna of Mossman Gorge is the green tree frog *Litoria caerulea*. A single specimen was observed on a small tree well away from water on a dry night. This species has not been observed breeding in the park.

The addition of these two species brings the total number of reptile and amphibian species encountered in the park to 23 and 13 respectively (Torr, 1993, 1996; Green and Turner, 1994).

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PREDATION ON A *POGONA SP.* BY *PSEUDONAJA TEXTILIS*

Bradley Oliver, 3 Fifteenth Street, Gawler SA 5118

The Eastern Brown Snake has been recorded feeding on a wide range of prey items with Shine (1989) listing: frogs, agamids, geckos, skinks, pygopods, lizard eggs, snakes, birds and mammals. This note records further predation on a *Pogona sp.* from South Australia.

On the evening of October 29, 1995 1 removed a Brown Snake from a backyard at Balaklava, 100km north of Adelaide. On capturing the animal I notice a large bulge in the snakes mid section which I assumed was a rat (*Rattus rattus*). I decided to retain the animal for future examination of the faeces. The snake was male with a snout vent length of 1170mm and weighed 500 grams.

On 2 November a fresh faecal sample was collected, and close examination revealed several small dehydrated infertile ova, insect fragments, dorsal scales, lateral scales and a digit consisting of a claw and two knuckles. From the size of the bulge, scales and the digit I decided the mid body swelling was a large *Pogona*. I was unable to determine the species as both *P. barbata* and *P. vitticeps* are found in the area surrounding Balaklava. The South Australian Museum has records of *P. vitticeps* from Bute, 50km northwest of Balaklava, and the closest record of *P. barbata* is a specimen found in a road killed Brown Snake (*P. textilis*) from Lower Light (See Fig. 1), 40km south of Balaklava (J. A. Abraham, pers. comm.).

The unfertilised ova found in the faeces measured 27mmx9mrn, which suggests that the dragon was a mature reproductive female. The insect fragments found in the faeces are very likely the contents of the dragon's gut.

Shine (1989) records two instances of Eastern Brown Snakes consuming *P. barbata*, one from New South Wales and one from the Northern Territory, and three instances of *P. vitticeps*, two from New South Wales and one from the Northern Territory.

Eastern Browns Snakes are known to consume large agamids and skinks such as *Tiliqua rugosa* (Mirtschin, 1991), *P. vitticeps* (Shine, 1989) and *P. barbata* (Shine, 1989, J A. Abraham, pers. comm.) and no doubt more examples will be recorded in the future.

ACKNOWLEDGMENTS

Thanks to the South Australian Museum, Jeff Abraham, Andrew Baker and Peter Mirtschin for their help in the preparation of this paper.

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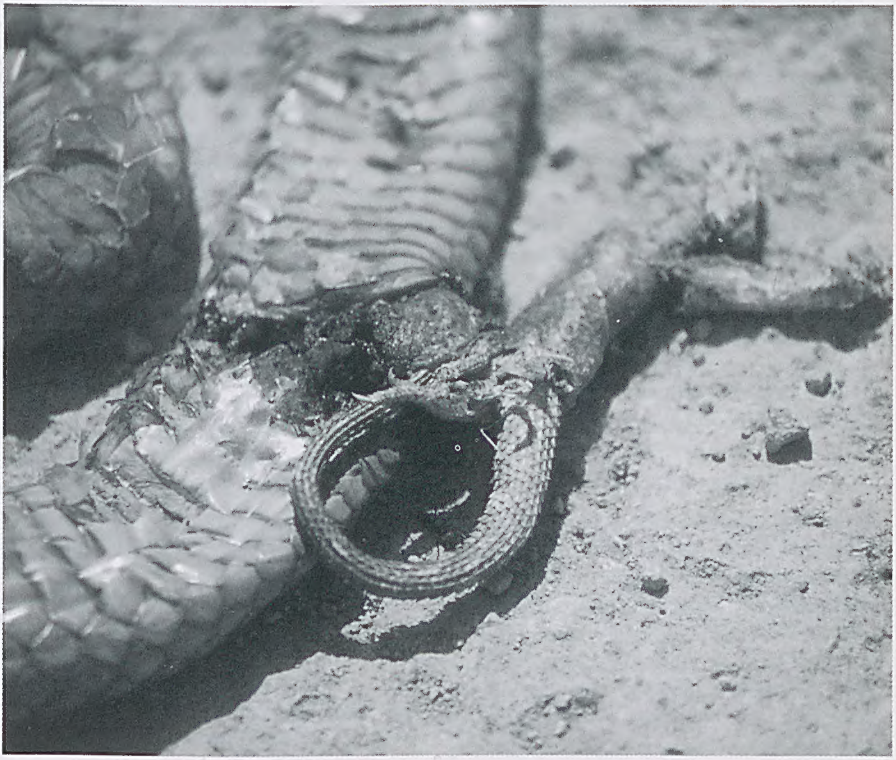
Figure 1 A road killed Eastern Brown Snake (P. textilis) found near Lower Light, 40km north of Adelaide, showing the partial remains of Eastern Bearded Dragon (P. barbata) in its stomach. (Photo by J. Abraham).



BOOK REVIEW

Günther R. (ed.). Die Amphibien und Reptilien Deutschlands. Gustav Fischer Verlag, Jena. 825pp. R.R.P. DM148.

With the recent reunification of Germany into a single country that comprises a large part of Europe, the time is appropriate for the appearance of this hefty reference work. Rainer Günther of the Zoologisches Museum in Berlin is to be congratulated for compiling the enormous range of information that is included. The single volume not only details the available knowledge of the German herpetofauna, but in the opening chapters summarises the history of German herpetofaunal studies and of German herpetologists (by F.J. Obst), describes the Quaternary fossil fauna (G. Böhme), and discusses the phylogenetic relationships of the modern German herpetofauna, making the book of value to more than just those interested in German reptiles and amphibians.

Following these opening chapters are detailed keys to genera and species, including for amphibians separate keys to eggs, larvae and adults. The species accounts for the 35 species of amphibians and reptiles which follow are separately authored, with 25 authors credited, although Günther is either co-author or sole author of all accounts but one (the brief account of introduced tortoises).

All but one species account, that for the Alpine Newt, *Triturus carnifex* (which barely reaches Germany), are lengthy, including details of taxonomic history, identification, coloration, size (both length and mass, partitioned, where known, by sex and locality, with sample sizes given), sexual dimorphism, reported anomalies, karyotype, distribution (including full page distribution maps with distribution based on records on an 11.5 x 11.5 km grid square system), habitat, associations with other species, shelter and hibernation sites, population density at study sites, call data (for amphibians), reproduction, development and growth, diet, predation and defensive behaviour, and conservation, all copiously referenced. The book ends in an 81 page reference list. Scattered throughout the text are 328 black and white drawings, photographs and graphs, with 16 colour plates between pp. 512-513. The plates have either five or six photographs to a page, and illustrate not only the species but also typical habitats. All illustrations are of good to excellent quality and are reproduced well.

In comparison to reference works on the Australian herpetofauna, the breadth of the information available in this work is astonishing. For some widespread species, such as the Common Toad, *Bufo bufo*, there are definite records for over 95% of the thousands of possible grid squares! This may reflect the accessibility of the German countryside. However, to have keys to eggs and larval amphibians, together with sonograrns and oscillograms of calls, and the detail given on size and ecology, is a level of sophistication way beyond the capacity of any current Australian reference work. Possibly part of the reason for this abundance of data is the low number of species involved. Researchers are not spread over such a diversity of taxa as in Australia. A second reason may be the interest in the systematics and behaviour of amphibians in Germany, particularly the waterfrogs, which have been the subject of an enormous amount of study by evolutionary biologists due to their propensity to hybridise. Certainly, the amphibian accounts are generally more detailed (only three of the 14 reptile accounts are over 18 pages long, with the longest 23 pages, while 15 of the 21 amphibian accounts are over 18 pages, with the longest (for *Rana temporaria*) being 44 pages).

It is clear that comparatively, knowledge of the Australian herpetofauna has a long way to go, with this book an excellent example of what can be achieved.

Glenn M. Shea, Dept of Veterinary Anatomy & Pathology, University of Sydney, NSW 2006.

NOTES TO CONTRIBUTORS

Herpetofauna publishes articles on any aspect of reptiles and amphibians. Articles are invited from interested authors particularly non-professional herpetologists and keepers. Priority is given to articles reporting field work, observations in the field and captive husbandry and breeding.

All material must be original and must not have been published elsewhere.

PUBLICATION POLICY

Authors are responsible for the accuracy of the information presented in any submitted article. Current taxonomic combinations should be used unless the article is itself of a taxonomic nature proposing new combinations or describing new species.

Original illustrations will be returned to the author, if requested, after publication.

SUBMISSION OF MANUSCRIPT

Two copies of the article (including any illustrations) should be submitted. Typewrite or handwrite (neatly) your manuscript in double spacing with a 25mm free margin all round on A4 size paper. Number the pages. Number the illustrations as Figure 1 etc., Table 1 etc., or Map 1 etc., and include a caption with each one. Either underline or italicise scientific names. Use each scientific name in full the first time, (eg *Delma australis*), subsequently it can be shortened (*D. australis*). Include a common name for each species.

The metric system should be used for measurements.

Place the authors name and address under the title.

Latitude and longitude of any localities mentioned should be indicated.

Use the Concise Oxford Dictionary for spelling checks.

Photographs – black and white prints are preferred but colour slides are acceptable.

Use a recent issue of *Herpetofauna* as a style guide.

A computer disc may be submitted instead of hard copy but this should not be done until after the manuscript has been reviewed and the referees' comments incorporated. Computer discs must be HD 1.44 mb 3.5" in Word for Windows; Wordperfect; Macintosh or ASCI. Any disc must also be accompanied by hard copy.

Articles should not exceed 12 typed double spaced pages in length, including any illustrations.

REFERENCES

Any references made to other published material must be cited in the text, giving the author, year of publication and the page numbers if necessary. At the end of the article a full reference list should be given in alphabetical order. (See this journal).

Manuscripts will be reviewed by up to three referees and acceptance will be decided by an editorial committee. Minor changes suggested by the referees will be incorporated into the article and proofs sent to the senior author for approval.

Significant changes will require the article to be revised and a fresh manuscript submitted.

REPRINTS

The senior author will receive 25 reprints of the article free of charge.

Pogona brevis, the black soil dragon from the Winton area Qld. See paper on p12.
(photo by Grant Turner)

Mixophyes balbus, the stuttering frog from the Nowra region. See paper on p2.
(photo by Garry Daly)